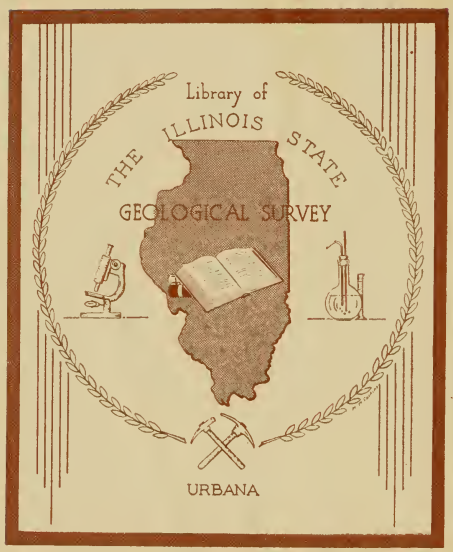

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ILLINOIS STATE GEOLOGICAL SURVEY
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C. K. Mohler,

May 22 1908,

Chicago. Ill.

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Illinois

State Geological Survey

BULLETIN NO. 4.

Year-Book for 1906

H. FOSTER BAIN,

DIRECTOR.

URBANA:
UNIVERSITY OF ILLINOIS.
1907

SPRINGFIELD, ILL.:
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1907

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STATE GEOLOGICAL COMMISSION.

GOVERNOR C. S. DENEEN, *Chairman.*

PROFESSOR T. C. CHAMBERLIN, *Vice-Chairman.*

PRESIDENT EDMUND J. JAMES, *Secretary.*

H. FOSTER BAIN, *Director.*

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STATE GEOLOGICAL SURVEY,
UNIVERSITY OF ILLINOIS, Feb. 12, 1907.

Governor C. S. Deneen, Chairman, and Members of the Geological Commission:

GENTLEMEN—I submit herewith material forming the Yearbook of the Survey for 1906, with the recommendation that it be printed as Bulletin 4. It includes the administrative report for the year, of which a small preliminary edition already has been printed, and a series of short papers giving as briefly as possible the important results of our first year's work. These should be considered as preliminary statements only, and more complete reports will be furnished as the investigation advances.

Several important studies which have absorbed much of the time of the survey corps are not represented in this report. These include especially the survey of the oil fields, the study of the water resources of the East St. Louis area, the detailed survey of the southern and central Illinois coal fields, and the geographic studies which are to be published in the educational bulletins. A report upon the oil fields already has been published, and it does not seem desirable to repeat any of the material merely to make the Yearbook complete. A report on the water resources of the East Saint Louis area and one of the educational bulletins are now ready for the printer and are expected to follow this bulletin promptly. The detailed survey of the coal fields, while it is being prosecuted with vigor, has not yet advanced sufficiently to warrant publication of results. Such general results as are now ready are given in the papers of Messrs. Weller, Fenneman and Savage, included in this report. Mr. Savage's work, while directed primarily to a study of the stratigraphy of the coal fields near Springfield, has yielded certain results bearing on water supplies, which it is thought worth while to publish here. His main results must await the completion of the survey of a larger area. This work is included in the plans for the coming field season.

Very respectfully,

H. FOSTER BAIN,
Director

ADMINISTRATIVE REPORT FOR 1906.

[By H. Foster Bain, Director.]

Contents.

Introduction.

History.—The study of the geology and the mineral resources of Illinois began in 1851, the Seventeenth General Assembly having passed an act providing for "A Geological and Mineralogical Survey of the State of Illinois." Under the provisions of this act Dr. J. C. Norwood was appointed State Geologist. He served six years and was succeeded by Dr. A. H. Worthen, who continued in the service of the State up to the time of his death in 1888. Small appropriations were made for the survey, and the publication of its results up to 1875, when the Twenty-ninth General Assembly failed to make an appropriation. The succeeding assembly in 1877 provided instead for a State Museum of Natural History, to which the collections of the Survey were transferred at the same time that Dr. Worthen was appointed curator. The museum has since been steadily maintained, though no funds have been available for field work.

In 1905 the Forty-fourth General Assembly provided for a resumption of field work under the following law:

AN ACT *to establish and create, at the University of Illinois, the bureau to be known as a State Geological Survey, defining its duties and providing for the preparation and publication of its reports and maps to illustrate the natural resources of the State, and making appropriation therefor.*

Section. 1. *Be it enacted by the People of the State of Illinois, represented in the General Assembly:* That there be and is hereby created and established at the University of Illinois a bureau, to be known as a State Geological Survey, which shall be under the direction of a commission, to be known as a State Geological Commission, composed of the Governor, who shall be *ex officio* chairman of said commission, the president of the Universit of Illinois, and one other competent person to be appointed by the Governor, who shall hold office for the term of four years and until his successor is appointed and qualified.

§ 2. The said commissioners shall serve without compensation, but shall be reimbursed for actual expenses incurred in the performance of their official duties; and said commissioners shall have general charge of such bureau and shall appoint a director, who may, with the approval of the board, appoint such assistants and employés as may be necessary to carry out the provisions of this Act.

§ 3. The director appointed under the provisions of this Act, and the assistants and employés appointed by him, as hereinbefore provided, shall receive such salaries or compensations as may be determined by the board of commissioners.

§ 4. The said bureau shall have for its objects and duties the following:

(1) A study of the geological formations of the State with special references to its products, *i. e.*, coals, ores, clays, building stones, cements, materials for use in the construction of roads, gas, mineral and artisian water and other mineral resources.

(2) The preparation of geological and other necessary maps to illustrate the resources of the State.

(3) The preparation of reports, with necessary illustrations and maps which shall include both a general and detail[ed] description of the geological and mineral resources of the State.

(4) The consideration of such other scientific and economic questions as in the judgment of the commissioners shall be deemed of value to the people.

§ 5. The regular and special reports of said bureau shall be printed and distributed and sold, as the commissioners shall deem best for the interest of the people of the State, and as they may direct; and all moneys obtained by the sale of said reports shall be paid into the State Treasury.

§ 6. The printing of said reports and of the necessary supplies of stationery, blank books and other printed matter necessary for the purpose of said bureau shall be and form a part of the State printing contract, and as such be under the direction and supervision of the Board of Commissioners of State Contracts; *provided, however*, that the cost thereof shall not exceed the sum of five thousand (5,000) dollars per annum.

§ 7. The director[s] shall present to the Governor an annual report showing the progress and condition of said bureau, together with such other information as the commissioners may deem necessary and useful.

§ 8. All materials collected, after having served the purpose of the bureau, shall be distributed by the director to the educational institutions of the State in such a manner as the commissioners may determine to be of the greatest advantage to the educational interests of the State, or, if deemed advisable, the whole or part of such material may be placed on permanent exhibition in the State Museum of Natural History at Springfield, or in the museums of the University of Illinois.

§ 9. The sum of twenty-five thousand (25,000) dollars per annum or as much thereof as may be necessary is hereby appropriated out of any money in the State Treasury, not otherwise appropriated, to provide for the payment of actual expenses incurred by the said commissioners in the performance of their official duties hereunder, and for other expenses or obligations authorized by them, and for the payment of the salary of the director appointed by said commissioners, and for the payment of salaries or other compensations of the assistants or other employés that may be appointed hereunder; and the Auditor of Public Accounts is hereby authorized and instructed to draw his warrant on the treasury for the allowance of said expenses and salaries upon the presentation of proper vouchers approved by the Governor.

§ 10. The said commissioners are hereby authorized to arrange with the director or the representative of the United States Geological Survey in regard to coöperation between the said United States Geological Survey and the said Geological Commission in the preparation and completion of a contour topographic survey and map or maps of this State, and said commission may accept or reject the work of the United States Geological Survey.

§ 11. In order to carry out the provisions of this Act it shall be lawful for any person or persons employed hereunder to enter and cross all lands within this State; *provided*, in doing so no damage is done to private property.

§ 12. The commission may expend in the prosecution of such coöperative work a sum equal to that which shall be expended thereon by the United States Geological Survey; *provided*, that not more than ten thousand (10,000) dollars be expended in this work in one year.

§ 13. That it shall be the duty of the University of Illinois to give thorough and reliable instruction in the geology of the clay working materials; their origin, classification, physical and chemical properties, and their behavior under such influences as are met with during the process of manufacture; and to provide for this purpose such instructor, laboratories, apparatus, and all illustrative material as may be necessary to make this instruction practical; and to carry out the provision of this section there is hereby authorized the sum of five thousand (5,000) dollars annually, and the Auditor of Public Accounts is hereby authorized to draw his warrants

on the State Treasurer for the sum appropriated in this section upon order of the chairman of the Board of Trustees of the University of Illinois, countersigned by the secretary and with the corporate seal of the University.

§ 14. All previous enactments which conflict with the provisions of this Act are hereby repealed.

Approved May 12, 1905.

Personelle.—Pursuant to this law the commission was organized by the appointment of Prof. T. C. Chamberlin of Chicago as the third member, and in September the present director was elected. He assumed office Nov. 1, 1905. A short time later the following additional appointments were made:

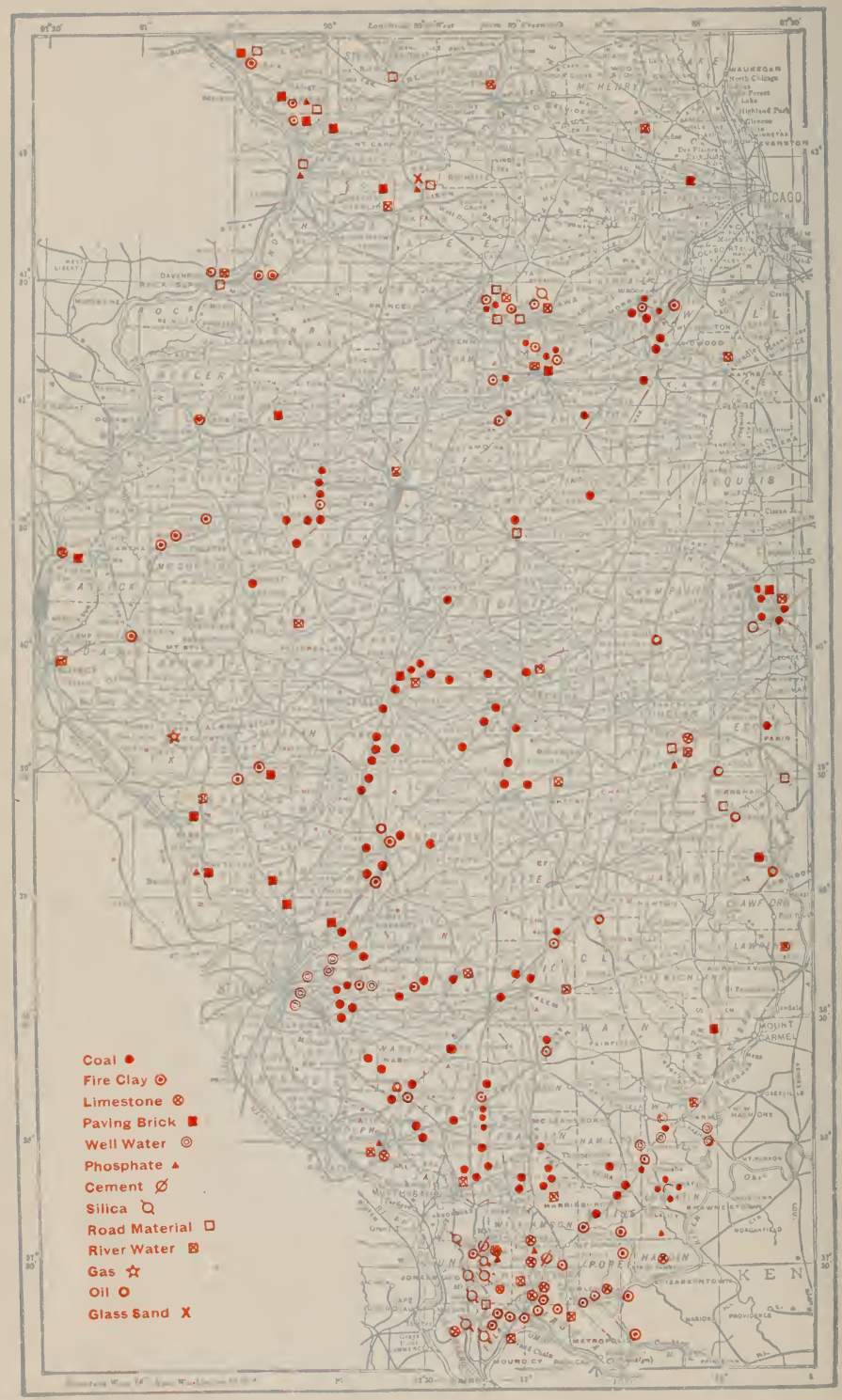
Prof. C. W. Rolfe, Consulting Geologist in Clay Investigations.
Prof. R. D. Salisbury, Consulting Geologist in Preparation of Educational Bulletins.
Prof. U. S. Grant, Consulting Geologist in Lead and Zinc Work.
Prof. S. W. Parr, Consulting Chemist in Coal Investigations.
Dr. Edward Bartow, Consulting Chemist in Water Investigations.
Dr. Stuart Weller, Geologist.
Mr. T. E. Savage, Geologist.
Dr. W. W. Atwood, Geologist.
Prof. J. A. Udden, Geologist.
Mr. R. C. Purdy, Ceramist.
Mr. F. B. Van Horn, Assistant Geologist.
Mr. A. W. Lewis, Assistant Geologist.
Mr. H. B. Fox, Assistant Geologist.
Mr. F. F. Grout, Assistant Chemist.

All of the above appointed promptly entered upon the discharge of their duties, and all are now connected with the survey with the exception of Messrs. Lewis, Atwood and Grout. Mr. Lewis resigned April 1 to conduct iron ore explorations in Canada. Mr. Atwood left July 1 to take up coal investigations in Alaska in connection with the United States Geological Survey, and Mr. Grout resigned in August to accept a position at Oklahoma University. Mr. W. F. Wheeler has been appointed in Mr. Grout's place. The other positions have been filled by temporary employés.

In addition to the above regular employés the following persons have been employed temporarily in the work of the survey:

Prof. W. S. Blatchley, State Geologist of Indiana.
Mr. E. T. Hancock, Michigan College of Mines.
Mr. H. H. Barrows, University of Chicago.
Mr. J. C. Carman, University of Chicago.
Dr. J. W. Goldthwait, Northwestern University.
Mr. M. J. Perdue, South Bend, Ind.
Dr. N. M. Fenneman, Wisconsin University.
Mr. J. C. Jones, University of Illinois.
Mr. Frank DeWolf, U. S. Geological Survey.
Mr. Isiah Bowman, Yale University.
Mr. Chester A. Reeds, Yale University.
Mr. E. M. Scheflow, Elgin, Ill.
Mr. Jon A. Udden, Rock Island, Ill.
Mr. J. J. Rutledge, Baltimore, Md.
Mr. Tom Moses, Springfield, Ill.

A number of the State Mine Inspectors have also from time to time performed voluntary service in connection with the survey, and a large number of individuals, as shown in Mr. Wilson's special report, have served in the topographic work. In the office Mr. C. B. Nolte and Mrs. Sadie A. Van Horn have served as clerks, while Messrs. D. F. Higgins, A. W. Harris and Guy R. Shaw have worked as draughtsmen.



Map showing localities from which samples have been collected for analysis or test

Organization.—In the reorganization of the Survey two major lines of work have been recognized, topographic and geologic. As was contemplated by the act establishing the Survey, the topographic work has been carried on in coöperation with the U. S. Geological Survey under the general supervision of Mr. H. M. Wilson, geographer of the U. S. Geological Survey, in charge of the Eastern Division of Topography, and under the immediate direction of Mr. C. E. Cooke in 1905, and in 1906 under Mr. W. F. Herron, topographer in charge of the Central Section.

At the beginning it was decided that the geologic work should be temporarily concentrated upon a study of the coals and clays of the State, these being its most important mineral resources. Provision was made for a small amount of work in connection with water, oil, lead, and zinc, and general stratigraphy with a view to later expansion. It was not found practicable with funds available to make any investigation of the cement materials or any other than a most general study of the quarry products and miscellaneous non-metallic minerals. Additional funds are urgently needed for this work.

Material and Subjects Investigated.

Something of the range of the survey work is indicated by the accompanying map upon which is marked the localities from which samples have been taken for analysis or other laboratory tests. A considerable number of different samples were taken from many of the localities noted. No account has been taken in preparing this map of general lithologic samples or collection of fossils made for office study. In the following pages are brief notes of what has been attempted in each case.

Coal.

The study of the coal and coal fields of the State has been carried on both in the field and office. The work has been directed toward—

(1) The solving of problems of stratigraphy such as the distribution and correlation of various coal beds, together with the collection of all data relating to the origin and the mode of deposition of the coal and accompanying beds.

(2) A study of the composition and uses of coals.

(3) A study of the mode of occurrence of coal as relates to the methods and costs of mining.

(4) A study of the preparation of the coal for the market, its transportation, its normal markets, and the competition which it meets.

Progress has been made mainly along the first two lines. In the case of the last two little has been done beyond the determination of the need of such work, its proper scope and the methods to be employed.

Stratigraphy.—A considerable portion of the funds of the survey have been devoted to stratigraphic studies of the coal measures, as is shown by the statement of expenditures given on the succeeding page. This was done because a thorough knowledge of the stratigraphy of the field is essential to its economical development, and for the further reason that money so spent advances the study of the associated clays,

limestones, cement materials, water, and other minerals as well as coal. The stratigraphic work is fundamental, and any investigation of more than limited or temporary usefulness must be founded upon an accurate and adequate study of the stratigraphy.

In order to reduce as much as possible the cost of this work to the State, an informal agreement has been entered into with the U. S. Geological Survey for coöperation. This takes the form of simultaneous studies by the two organizations of different parts of the field with exchange of results. Under this arrangement Mr. T. E. Savage, of the State Survey, made a detailed study of the Springfield quadrangle, and Prof. J. A. Udden, assisted in part by Mr. Jon A. Udden, of the Peoria quadrangle. In this work State Mine Inspector James Taylor served as volunteer assistant and contributed greatly to the practical character of the work.

On behalf of the U. S. Geological Survey, Mr. Frank W. DeWolf in July took up the study of the New Haven and Eldorado quadrangles in the southern part of the State. It is proposed to extend these surveys west to cover the whole of the rapidly growing southern Illinois coal fields. Mr. David White, of the U. S. Geological Survey, took up the general study of the stratigraphy of the coal measures as shown by the fossil plants, and Dr. Stuart Weller, of the State Survey, began a similar study of the Carboniferous formations, with especial reference to the distribution of marine invertebrates. Both Mr. White and Dr Weller served with the State and federal field parties without distinction, and it is believed that this careful study from both points of view will be productive of extremely valuable results. The general nature of the work done by Mr. White and something of his results is told in a brief report submitted herewith.

In further coöperation with the U. S. Geological Survey a detailed study of the St. Louis-East St. Louis area was also made. Geological formations do not respect state boundaries, and to obtain comprehensive results it is often necessary to make surveys of portions of adjacent states. The St. Louis limestone, one of the very important formations in Illinois, has its type locality across the river in Missouri, and the Cheltenham fire clay, although having extensions in our State, is also best studied in the city of St. Louis. We were therefore fortunate in being able to join the U. S. Survey in a simultaneous study of both sides of the river at this point. This work was under the immediate charge of Dr. N. M. Fenneman, of Wisconsin University, acting for the U. S. Survey, but was participated in by Messrs. Weller, Jones and Purdy, of the State Survey, and White of the federal organization. The expenses of the work were divided between the two surveys. A brief preliminary statement of the results has been prepared and is published on later pages.

As a first step in the correlation of the various coal beds, maps have been collected showing the correlations now made by different engineers familiar with the field. Such a map, courteously prepared for us by Mr. A. Bement, of Chicago, was published in our Bulletin 3 to serve until such a time as our own studies would permit the expression of opinion.

Compositions and Uses of Coal.—Investigations along these lines have been taken up in coöperation with the Department of Applied Chemistry and the Engineering Experiment Station of the University. The chemical work has been done under the direction of Professor Parr and has been directed to a study of both the ultimate and proximate composition of coals. As a first step in the work Professor Parr has brought together such existing analyses of Illinois coals as seemed reliable, and has prepared a preliminary report forming Bulletin No. 3 of the present series. In this bulletin the results of 150 analyses of Illinois coals are compared. An interesting result of this work has been the development of the fact that a considerable portion of the volatile matter of the coal as ordinarily determined has really no heat value. This is a fact of considerable economic as well as scientific importance. Professor Parr has also developed a new classification of coals which seems likely to prove widely applicable and of considerable usefulness.

The analyses used in this preliminary work were not made upon samples collected by our own men according to any uniform method. It is accordingly impossible to say how accurately they represent the facts of coal field. For this reason a wholly new set of samples has been collected preparatory to further studies. The new samples have been cut in the mine from a clean face of coal, taking the entire workable thickness of the bed and marking on an accompanying section all partings included as well as rejected in sampling. The samples were promptly quartered down and shipped in an air-tight galvanized iron can so as to arrive in the laboratory without loss or gain in the natural moisture. Whatever additional sampling may prove later to be necessary, it was thought that the first step must be the careful determination of the composition of coal as it is in the ground. Messrs. Grout, Rutledge, Lewis and De Wolf have taken samples according to this method in various parts of the State. In this work we have had the valuable assistance of Mr. Tom Moses, Secretary of the State Mining Board, who served as volunteer assistant. In all 166 are now available for study. It is proposed to increase the number as opportunity serves.

The coal samples have been powdered and prepared, and results of proximate and ultimate analyses, as well as B. T. U. determinations, run on both the Parr and Mahler calorimeters, are now available for the first twenty-five. Professor Parr has prepared a paper discussing these results, which will be separately submitted.

A somewhat similar line of investigation, the effect of weathering on the fuel value of coals, has also been taken up. A number of tests are being run to determine the amount of oxidation and of decomposition which takes place in coal exposed for a series of months under various conditions. It is hoped that these, when checked by studies of the amount of mechanical disintegration, may afford data upon which a proper system of coal storage may be founded.

In connection with the Engineering Experiment Station a study of washed coals has been begun. It is felt that better preparation of coal for the market is a matter of supreme importance, particularly to the extent that it may reduce the amount of smoke made in burning. The

Engineering Experiment Station has under way a series of boiler trials on the same coal washed and unwashed, and the Survey is coöperating with the Station in this work.

Mode of Occurrence.—To a very important degree, the mode of occurrence of the coal and the character of the roof shales and floor clay determines the method of mining and the cost of the work. Thorough studies along these lines are highly desirable. A beginning has been made in connection with the work of sampling the veins and the stratigraphical work already discussed. At Peoria Professor Udden and Mr. Taylor have made detailed studies of the puzzling series of faults which have interfered seriously in places with mining. At Springfield the horsebacks have been investigated by Mr. Savage, and at other points in the State similar phenomena have been under view. A much more thorough and complete investigation should be undertaken, and undoubtedly would be productive of results of value. One phase of the subject of pressing importance is the occurrence of gases in mines and their influence in causing and extending explosions. The loss of life and property as a result of explosions in the coal mines is a constant and serious burden. In the six years ending June 30, 1906, 869 lives were lost in our mines. Of these 226 were due to explosions of one sort or another. There should be a thorough and comprehensive investigation of the entire subject to the end that proper precautions may be adopted to prevent or minimize this loss. As a larger number of deep mines is opened in the State it is to be expected that more gas will be encountered, and preparations should be made to meet these conditions.

Markets.—The study of the marketing of our coals is only incidentally a part of the survey work, but it is one of great importance and may be made of the greatest value to the State. For some years the capacity of our mines has been ahead of the demand, and with the increasing demand for smokeless fuel, eastern coals have cut into the markets naturally belonging to Illinois. Much good can be done by disseminating correct information regarding methods of burning so as to produce the minimum of smoke. Probably also good results would follow a careful study of the particular demands of our natural markets as regards size of coal. To the extent that it may prove possible it is proposed that the Survey shall assist in this work.

Clay.

The investigation of the clays has been carried on in connection with the Department of Ceramics of the State University, Professor C. W. Rolfe serving as Consulting Geologist and Mr. R. C. Purdy as Ceramist. Associated with them were Messrs. J. F. Krehbiel, J. K. Moore, A. J. Ellis, H. L. Bushnell, C. E. Merry, and others. Professors A. N. Talbot and Ira O. Baker undertook portions of this work. The chemical work was done under the direction of Profesor Parr by Messrs. F. F. Grout, Deane Burns, H. A. Scholz and David Klein.

The principal work of the year has been a study of paving brick clays. This has involved visits to all the paving brick plants of the State, with a study of their processes and the thorough testing of samples of their products. In addition barrel samples of the clay have

been shipped to the laboratory, prepared and burned under known conditions and results noted. For purposes of comparison similar samples of clay and brick from the leading plants in Ohio, Indiana, Missouri and Kansas have been collected and also tested. In the collection of these samples we have had the active assistance of State Geologist Orton, and F. H. Riddle in Ohio, of Professor E. M. Shepard in Missouri, and of State Geologist Haworth and F. J. Campbern in Kansas.

The results of the various tests are now being tabulated and a report on the subject will be ready for printing shortly. The investigations show not only that we have large resources of excellent material in Illinois, but also throw important light upon the technology of paving brick making.

A second line of investigation taken up within the year was a preliminary study of the fire clays of the State. Samples of the Paleozoic fire clays were collected by Messrs. Hancock, Van Horn, Grout, Moses, Rutledge and Fox; while Mr. De Wolf in the course of a reconnaissance of the southern part of the State in May and June, collected numerous samples of the Mesozoic clays. These have been tested in a preliminary way by Messrs. Purdy and Krehbiel, and a report on the subject has been prepared by Messrs. De Wolf and Purdy. It is to be regretted that there was no time for a more thorough study, but it seems advisable to print such data as are available and leave until later a more complete study. In all 46 clays were examined, and of these 39 stood a fire test equivalent to 1670 degrees centigrade or higher, and may accordingly be considered refractory. Many of the remaining may be used in situations where a lower heat is sufficient.

Much more work is needed on the fire clays and in addition the pottery clays, terra cotta clays and various building brick clays demand investigation. Second only to coal, our clay working industries are the most important ones founded on our mineral resources. In 1905 the total value of the clay output amounted to $12,392,000.00, and in 1906 there was a substantial gain.

Water Resources.

Adequate supplies of pure water for municipal and industrial purposes are becoming harder to obtain year by year. As the population becomes denser this difficulty is likely to increase. Since the distribution and occurrence of water is a geological problem, the Survey has taken up studies designated to throw light upon water resources and water supply. In this work it has coöperated with the State Water Survey, the Engineering Experiment Station, and the U. S. Geological Survey under terms of general agreement quoted below:

This Agreement, made and entered into this first day of July, 1906, between Charles D. Walcott, director, for and on behalf of the United States Geological Survey, of the first part; Edward Bartow, director, for and on behalf of the State Water Survey of Illinois, of the second part; L. P. Breckenridge, director, for and on behalf of the Engineering Experiment Station of Illinois, of the third part; and H. Foster Bain, State Geologist, for and on behalf of the State Geological Survey of Illinois, of the fourth part.

Witnesseths It is hereby agreed that there shall be conducted in the State of Illinois a coöperative survey to determine as hereinafter provided,

the character and applicability of the natural waters of said State, during a period of twelve months from July 1st, 1906, and that the parties hereunto subscribed shall contribute to the support of said survey as follows:

By the party of the first part	$3,000 00
By the party of the second part	3,200 00
By the party of the third part	1,000 00
By the party of the fourth part	1,000 00
Total	$8,200 00

1. That all work performed under this coöperative agreement shall be confined to the determination of the mineral and organic constituents in the surface and ground waters of said State, their applicability for use for industrial and domestic purposes, and their pollution by sewage, together with certain experimental work: (*a*) upon the effectiveness of sewage purification plants now installed within the State; (*b*) upon the reaction of different types of water in the production of steam in boilers, with studies of boiler scale corrosion and foaming; (*c*) upon a comparative study of methods for the prevention of the growth of crenothrix and in addition thereto such special studies as may be determined upon by the Board of Control hereinafter designated.

2. That the work performed under this coöperative agreement shall be under the direction of the Board of Control composed of representatives designated by the parties hereunto and until further action by the parties shall be as follows:

For the party of the first part, M. O. Leighton.

For the party of the second part, Edward Bartow.

For the party of the third part, L. P. Breckenridge, Arthur N. Talbot, and Samuel W. Parr.

For the party of the fourth part, H. Foster Bain.

It is hereby understood and agreed that in case of a division of opinion in the Board of Control with reference to the disposition of any of the matters over which said board is placed in control under the terms of this agreement, that each of the parties to this agreement shall be entitled to but one vote.

3. That Edward Bartow is hereby designated as administrative director of the investigations provided under this agreement, and shall have in charge the approval of accounts for disbursement, and shall, with the approval and consent of the Board of Control, engage the services and fix the compensation of such assistants as are required for the carrying on of the work herein provided, with the exception of those assistants especially appointed under this agreement.

4. That a member of the staff of the United States Geological Survey, duly classified by the United States Civil Service Commission, shall be designated to carry on a part of the work provided under this agreement, the nature of which shall be determined upon by the Board of Control, and that said official shall be paid the sum of fourteen hundred (1,400) dollars per year for such services.

5. That the three thousand dollars contributed by the party of the first part to the support of the work provided under this agreement shall be expended, so far as it is possible, for the salary of the member of the staff of the United States Geological Survey, and those of such other assistants as may be designated by the Board of Control, the total amount of such salaries not exceeding the contribution by the party of the first part, and that all accounts be paid by the party of the first part shall be prepared and audited in accordance with the rules and regulations of the United States Geological Survey and of the United States Treasury Department.

6. That thirty-two hundred dollars contributed by the party of the second part and one thousand dollars contributed by the party of the third part, shall be expended for assistance, traveling expenses, clerical work, supplies and equipment, and such other incidental purchases and expenses as may be determined on by the Board of Control with the approval and consent of the representatives of said parties.

Proviso: In view of the fact that the State Board of Health has furnished a bacteriologist, at a salary of $1,000.00 per year, whose services are available for the proposed coöperative investigation, and has agreed that the sanitary engineer of the State Board of Health will collect samples from sewage disposal works, and that the medical inspector will collect water from suspected supplies, the contribution by the party of the second part is made with the understanding that the party of the second part shall be free to make for the State Board of Health, bacteriological and chemical examination of suspected water and sewage, not to exceed 500 in number.

7. That the one thousand dollars contributed by the party of the fourth part shall be expended as follows: (1) Seven hundred dollars to be expended by and under the direction of said party of the fourth part in conference with the administrative director of these investigations; of which five hundred and fifty dollars shall be devoted to a study of the ground waters of the East St. Louis district, and one hundred and fifty dollars to the collection and transportation of samples of well waters from selected points throughout the State, and to preliminary studies of the water horizons of the State. (2) Three hundred dollars of the money contributed shall be expended by said administrative officer for salaries, chemicals, or incidental expenses of this investigation as he shall deem best.

8. That the party of the second part shall provide a suitably equipped laboratory for chemical and bacteriological work, and that in case it shall be necessary to provide extra equipment for the purposes of the investigation herein specified, the cost of such additional equipment shall be paid from any moneys remaining in the fund not otherwise allotted.

9. That there shall be established along the rivers and at points designated by the Board of Control sampling stations from which there shall be sent daily samples to the laboratory of the State Water Survey at Urbana, such samples to be sent by mail in four-ounce bottles, under the authority of the party of the first part and with the franking privilege accorded to such party by law. That these samples shall be stored for definite periods in such laboratory, and analyses of the composite from each sampling station shall be made at intervals to be determined by the Board of Control. That the determinations to be made upon such composite samples shall be determined by the Board of Control and when not otherwise specified shall be the following: Silica, iron, alumina, calcium, magnesium, sodium, potassium, sulphurtroxide, chlorine, carbondioxide, turbity (U. S. Geological Survey standard), suspended matter, and dissolved solids; such determinations to be expressed in parts per million and in ionic form.

10. The samples of ground waters from points designated by the Board of Control shall be sent to the above designated laboratory for mineral analysis, the determinations and expressions of results to be the same as that described in the foregoing section of this agreement, and in addition thereto shall be made such other special determinations for defined purposes as may be agreed upon and directed by the Board of Control.

11. That there shall be carried on special experiments upon the effect of the various Illinois waters upon steam producing boilers which shall include a study of the types of such waters with reference to their reaction in boilers, the methods of analysis and the methods of installation of steam apparatus indicated by the various chemical processes revealed and also the corrosion caused by steam waters together with experiments to show the relation between the composition of the water and its tendency to corrode, foam or cause scale, and such other special work as may from time to time be directed by the Board of Control.

12. That samples shall be collected from the public water supplies of the State for the sanitary analysis, for the purpose of determining the potability of such supplies. Such analyses shall include the determination of bacteria and the presence or absence of bacillus coli communis, according to standard methods, promulgated by the American Public Health Association. That similar analyses shall be made of the river water at chosen distances below points of pollution to determine the persistence of contaminating matter, the specific determinations to be made in connection with these investigations to be based upon the special problem in each case and to be designated by the

Board of Control. Such investigations shall be extended to private water supplies whenever in the opinion of the Board of Control such analyses are desirable. It is understood and agreed that the work indicated in this section shall apply both to surface and to ground waters.

13. That there shall be maintained a series of experiments upon the best methods of treating water supplies subject to pollution of various kinds and to the disorders due to microscopic organisms such as crenothrix, these investigations to be designated as "Experimental Work upon the Treatment of Water," and the extent of the work and the character of the tests shall be determined by the Board of Control.

14. The provisional allotments for the various investigations herein provided shall be made according to the following schedule, it being understood and agreed that in case experience shall show that a change in such allotments will be of advantage to the work, such change may be made by the Board of Control:

Mineral analyses—	
Surface waters	$1,830 00
Ground waters	1,300 00
Boiler waters	1,600 00
Sanitary analyses—	
Surface waters	1,000 00
Ground waters	900 00
Experimental work upon treatment of waters	1,000 00
Incidentals and equipment	570 00
Total	$8,200 00

15. That in case it shall be found previous to the close of the term of this contract that the expenses incurred under this agreement will be greater than the total amount of the fund provided, retrenchment shall be made by suspension, according to the decision of the Board of Control.

16. That in case the expenses of the work outlined in this agreement should not be as great as the fund provided, adjustment shall be made in the last month of the term of the contract by paying salaries and expenses from the various allotments in such a way that the expenditures of each party hereunto subscribed shall be an equal proportion of the amount contributed by each to the fund.

17. And, be it understood and agreed that the original notes and records of the work performed under this contract shall be kept in the custody of the administrative director and copies thereof issued to the several parties to this agreement upon demand. That each of said parties shall have the right to use any of the results as may be of value in its special line of work for the purposes of publication, but that the publication of the results of the entire series of investigations as a whole shall be reserved to the party of the first part. In the publication of said reports by the party of the first part, the relationship of each party to the report shall be clearly stated, and each party shall be provided with an equitable number of copies thereof to be distributed according to the provisions of any statutes by which either party may be governed.

In testimony whereof, we have hereunto set our hands the date and year first written herein.

CHARLES D. WALCOTT,
Director U. S. Geological Survey, for and on behalf of the party of the first part.

EDWARD BARTOW,
Director State Water Survey of Illinois, for and on behalf of the party of the second part.

L. P. BRECKENRIDGE,
Director Engineering Experiment Station of the University of Illinois, for and on behalf of the party of the third part.

H. FOSTER BAIN,
Director State Geological Survey, for and on behalf of the party of the fourth part.

In accordance with paragraph 3 of the agreement, Mr. Isaiah Bowman and Mr. Chester A. Reeds were assigned by the State Geological Survey to summer field work in the East St. Louis Quadrangle. In connection with their study of the area, twenty-four samples of water were sent in to the State Water Survey Laboratory, analyses of which were made by Mr. W. F. Wheeler.

For the collection of daily samples of water, twenty-six stations, as shown on the accompanying sample map, were established in the State during the latter part of July. Samples have been shipped regularly since Aug. 1 from the following places:

Location.	Stream	Location.	Stream.
Carlyle	Kaskaskia river	Marion	Reservoir
Carmi	Little Wabash river	Menard	Mississippi river
Cartter	Reservoir.	Moline	Mississippi river
Chandlerville	Sangamon river	Mounds	Cache river
Charleston	Embarass river	Murphysborro	Big Muddy river
Cypress	Reservoir	Ottawa	Fox river
Danville	Big Vermilion river	Peoria	Illinois river
Decatur	Sangamon river	Quincy	Mississippi river
Elgin	Fox river,	Rock Falls	Rock river
Joppa	Reservoir	Rockford	Rock river
Kampsville	Illinois river	Shelbyville	Kaskaskia river
Kankakee	Kankakee river	Springfield	Sangamon river
LaSalle	Illinois river	Sterling	Rock river
Lawrenceville	Embarass river	Streator	Vermilion river

The detailed study of the water resources of the East St. Louis district were undertaken in June. In a district of so many and such varied manufacturing interests as that extending from Alton to Belleville, water problems are numerous and difficult. The work was begun in coöperation with the Eastern Section of Hydrology of the U. S. Geological Survey, M. L. Fuller in charge, but in June, owing to the decreased appropriations being made by Congress, the entire work was transferred to the State and became a part of the general coöperative work on water as provided in the above agreement. At this time all the notes previously collected were turned over to the State. The report has been finished and illustrations are now being prepared. Many points of interest to the water users were found by Messrs. Bowman and Reeds, and it is believed that their conclusions will prove of large value to the people of the district concerned.

Dr. E. A. Bartow, Director of the State Water Survey and Consulting Chemist to the Geological Survey, has undertaken to prepare a general report upon the nature of the underground waters of the State, as regards their distribution, classification, therapeutic values and uses. This work is now under way. To accompany this Professor J. A. Udden has prepared a chapter on the underground water horizons, but a much more complete discussion of the artesian possibilities of the region is badly needed.

Another line of investigation, which it has been suggested the Geological Survey should take up, relates to the swamp and overflowed lands, the action of rivers, and the methods of drainage. Large areas of land have already been reclaimed by drainage, and many local drainage districts are now in existence. When, however, the problem of the control of a whole river such as the Sangamon, Kaskaskia,

Embarass or Little Wabash is approached, it is at once found that the data are not now available upon which to plan a comprehensive and economical system. Numerous stream gaugings are needed, the area of the water shed, the rainfall and the regime of the main river and its tributaries must be studied if the best system of river control is to be adopted. The topographic maps now being made by the survey will afford much of this data, but other material can only be obtained as a result of special study. Land is becoming exceedingly valuable in Illinois, and a wise provision for the future would suggest the reclaiming of every available acre. In order to prevent waste and misdirection in expenditure, a certain amount of preliminary study should be devoted to the problem, and at the same time the surveys of the river valleys should be advanced as rapidly as possible. While there have been numerous demands for the survey to take up this work, the director and the commissioners have not felt free to do so, with the resulting diversion of funds from other lines of investigation, and a special appropriation should be provided if the work is to be done.

Oil and Gas.

Important deposits of petroleum were discovered in southeastern Illinois late in 1904. Shipments began in June, 1905, and by August, 1906, the output had grown to 800,000 barrels for the month, approximately equaling the output of Indiana for the corresponding month of the preceding year. The total output for 1906 will fall but a little below half the output of Indiana for the preceding year. This development has been exceedingly gratifying. Promptly after the organization of the geological branch of the survey steps were taken to make a proper study of this important new mineral resource. Mr. A. W. Lewis spent some time in the field determining its general outline and collecting such well records as were available. In April and May the entire field as then developed was studied for us by Professor W. S. Blatchley of Indianapolis, an experienced oil expert and State Geologist of Indiana. Professor Blatchley's conclusions were most encouraging, and his report, froming Bulletin 2 of the present series, was promptly sent to the printers. In this bulletin the origin, distribution, and methods of producing the oil were discussed in such detail as the then available data would permit. Analyses of representative samples were added and a list of bench marks given. The latter was based on a series of levels run through the region for the survey by Mr. E. M. Scheflow, assisted by Mr. Loren Digby. Some 117 points of accurate elevation were established for use in correlating oil sands and marked by suitable brass tags.

In addition to this discussion of the southeastern Illinois petroleum field, brief notes on oil and gas discoveries in Pike, Montgomery, Randolph, Saline and Williamson counties, written by various other members of the survey, were appended. The oil field has continued to rapidly develop and additional surveys will soon be necessary. The large volume of gas now being found, estimated at 50,000,000 cubic feet per day, also demands investigation. Steps should be taken in particular to prevent its further waste.

Educational Bulletins.

Following the example of some of the other states, the Geological Survey of Illinois has planned the publication of a series of educational bulletins. They have been called educational, because their purpose is to put useful information concerning the geology and geography of the State, or some parts of it, before those who are not special students of those sciences. More particularly, their purpose is to put into available form such knowledge as will help those who are not geologists in understanding the common phenomena of their own regions. The bulletins are therefore intended to serve the citizens at large, rather than special students of geology, or special industries of the State which depend, directly or indirectly, on the mineral resources. Other and more technical publications serve this latter purpose.

Two classes of people are kept especially in mind in the preparation of these bulletins. These are (1) intelligent cititzens whose atention, for one reason or another, has never been directed to geology. Among such citizens there are always some who are interested in understanding their home regions; and through the understanding of one region the general principles of geology are grasped, in some measure at least. The knowledge thus acquired may be a source of much satisfaction to those who possess it. Furthermore, there is always the possibility that occasion may arise in the future when the information can be turned to account in economic ways.

(2) The study of physical geography and geology is now pursued somewhat generally in high schools, and might be pursued with great advantage much more widely than it is now in the country schools. According to the improved methods of study at the present time, it is essential that the subjects studied be so illustrated and applied that the knowledge acquired becomes a part of the student's permanent equipment. His study of physical geography fails of its full purpose unless it puts him into possession of the ability to interpret the surface of the land as he travels to and fro in after life. The best way to acquire this ability appears to be to make application of principles studied in the school to the phenomena of the region in which the school is located. Many of the principles of physical geography and geology are illustrated within easy reach of most of the schools in the State.

A second purpose of these bulletins, therefore, is to put the schools of the various parts of the State into possession of a general account of the principal geographic and geological features of their regions, which may be used as a sort of field book. This field study in physical geography serves the same purpose as laboratory work in physics and chemistry, in connection with those subjects.

It will be long before all the important regions of the State can be covered in this way. In the choice of areas selected for early treatment, three considerations control. These are the following: (1) Areas of great inherent interest will take precedence over those not so favored. (2) Areas of which topographic maps have been made will take precedence over those not so mapped; and (3) areas where

the bulletins are likely to be widely used will have precedence over other areas. The areas which will receive early consideration are the areas where these three conditions are found.

The topographic maps have been made for but relatively small portions of the State, so that, at the present time, the larger part of the area of the State is ruled out of the immediate consideration in this connection.

This work has been placed in charge of Professor R. D. Salisbury of the University of Chicago, Consulting Geologist of the Survey. Five bulletins have been undertaken. One of them has been completed. The field work for three others has been essentially completed, while the work for the fifth is under way. One of the bulletins concerns the region along the shore of Lake Michigan, north of Chicago; a second deals with the valley of the Desplaines river; a third deals with the valley of the Illinois from Hennepin to Pekin; a fourth with the area about East St. Louis; and a fifth (jointly with the Geological Survey of Iowa) deals with the Mississippi valley from Savanna on the north to Davenport and Rock Island on the south.

The first of these bulletins, prepared by Dr. Wallace W. Atwood and Dr. J. W. Goldthwait, attempts to put into available and popular form present knowledge concerning the geographic development of the region of which it treats. Among other topics it deals with the successive stages in the history of Lake Michigan, and the ways in which the former expanded lake affected the surface.

The second bulletin, by Doctor Goldthwait, which deals in part with the outlet of the ancestral Lake Michigan, is closely connected with the first, but deals with other problems as well, especially with glaciation and river erosion and their effects on the present surface.

The third bulletin, by Mr. H. H. Barrows, besides dealing with the general physiography of the region concerned, will discuss several of the distinctive features of this valley, such as the striking narrowings and widenings, the terraces, which are one of the pronounced features of this valley; the alluvial fans, which have an unusual development considering the relief and climate of the region, and the influence of the geology on the industrial development of the region.

The fourth bulletin, by Professor N. M. Fenneman, will explain the general physiography of the region about St. Louis, which will furnish some important data concerning the date of excavation of the Mississippi valley—data which have some bearing on the crustal movements in late geological times; a discussion of river deposition, which is well illustrated by the main valley of the region; and discussions of a number of minor points which find illustration in this region.

The fifth bulletin, by J. E. Carman, besides presenting a general sketch of the history of the present topography, will discuss the somewhat extensive deposits of sand and loess made by the wind; the origin of certain lacustrine or fluvio-lacustrine deposits in some of the tributary valleys; the effect of glaciation on the present surface, and the history of drainage changes. The last point is of much interest since the course of the Mississippi and of some other streams has been changed very notably, as the great valleys unoccupied or occupied by small streams show.

The next bulletin undertaken will probably deal with the Illinois valley between the mouth of the Desplaines and Hennepin.

In each of these regions there are factors of interest geographically, and in each there are important schools to be served. Each region, too, is relatively populous.

In some cases the work done in the preparation of these bulletins will probably lead to the development of information of importance, but in regions the geology of which is well understood they may do little more than put into available form the information which geologists already possess. Their value is not to be underestimated on this account, for the State which supports the survey has a right to information in such form that it may be available for the people.

It is the purpose of the survey to undertake the publication of similar bulletins about cities and villages in which are important educational institutions, as soon as practicable after topographic maps are available. The areas about State normal schools might appropriately receive early attention, but the areas about none of the normal schools have topographic maps at present, and without such maps the bulletins would fail of much of their purpose.

Lead and Zinc.

The ores of these metals are found in both the northern and southern parts of the State, and mining is now being carried on in JoDaviess, Pope and Hardin counties. In the first named county the search for zinc has been particularly active in recent years. The director of the survey, before assuming his present position, made a general study of these mines for the U. S. Geological Survey,* as well as a general study of the whole upper Mississippi valley zinc and lead region. Supplementary to this study detailed maps are needed throughout the productive area. A beginning has been made toward supplying this need. The work has been placed in charge of Dr. U. S. Grant of Northwestern University, Consulting Geologist of the Survey. Dr. Grant recently mapped the most productive areas in Wisconsin, and it is planned to cover the Illinois field as it develops with maps similar in character.

This season the Vinegar Hill area, including nearly fifteen square miles, was surveyed on a scale of four inches to the mile by Dr. Grant and Mr. M. J. Perdue, assisted by Mr. E. M. Scheflow, levelman. A detailed topographic and geologic map was made and on it were placed structural contours from which the depth to the "oil rock" can be obtained at any point. As the "oil rock" and the beds immediately above it form the most productive horizon in the region, the map should be of great assistance in the development of the deposits. The map is now being engraved, and will be published as promptly as possible. It is proposed to extend these surveys to cover the whole of the productive area. As a preliminary step in this direction, the primary traverse and the primary level lines were this year run so as to permit

* Zinc and Lead Deposits of Northwestern Illinois; U. S. Geol. Surv. Bull. 246.

† Zinc and Lead Deposits of the Upper Mississippi Valley; U. S. Geol. Surv. Bull. 294. (In press.)

of a topographic map being made of the Apple River and Galena quadrangles. This map will be upon the usual inch to the mile scale, and will supplement the large scale general maps.

In southern Illinois very little zinc has so far been found, though the lead ore is steadily shipped as a by-product of fluorspar mining. When the topographic survey of the southern Illinois coal field has sufficiently advanced, it is planned to take up the mapping of the fluorspar-lead district. The primary traverse and the level work is planned for 1907. In the meantime a general report upon the area, published by the U. S. Geological Survey,* is available. An interesting development of the year has been the finding of silver values in the lead ore sufficient to form an element in the purchase price. Of recent years the price of silver has been so low that the small amount of silver found in the galena was not paid for by the smelter.

Fluorspar.

The fluorspar deposits in Pope county are among the largest and most important in the world. In 1905 they yielded 33,275 tons of spar, having a value of $220,260.00. Some lead is found with the spar. Fluorspar is used mainly as a flux in steel making and in the enamelling trades, but also has a umber of minor uses. As promptly as possible the geological mapping should be extended to cover the fluorspar districts and studies of the uses of spar should be made so as to widen the markets as much as possible.

Quarry Products.

Highway Materials.—In connection with the State Highway Commission, samples of rock and gravel now in use in the construction of roads have been collected at a number of points. These materials have been tested in the road material laboratory and reports have been duly forwarded to State Highway Engineer Johnson. The localities from which samples were collected are indicated on the accompanying sample map, and are listed below:

Gravel, Charleston, Ill., collected by Savage. Test No. 24.

Crushed rock, Garrison's quarry, N. E. ¼ section 28, Casey township, Clark county; collected by Savage. Test No. 27 .

Novaculite (flint) from Tammus, Alexander county; collected by DeWolf. Test No. 26.

Gravel, Bloomington, Ill., (near water works); collected by Hancock. Test No. 31.

Crushed rock, Utica, Ill., Sec. 8, T. 33 N., R. 11 E., Utica township; collected by Hancock. Test No. 36.

Crushed rock, Deer Park, near LaSalle, Sec. 33, T. 33 N., R. 1 E.; collected by Hancock. Test No. 37.

Crushed rock, one and one-half miles southwest of Ottawa, Sec. 15, T. 33 N., R. 3 E.; collected by Hancock. Test No. 39.

Crushed rock, Dixon, Ill., Sec. 33, T. 22 N., R. 9 E.; collected by Hancock. Test No. 40.

Crushed rock, Savanna, Ill., near C. B. & Q. R. R. tracks in north edge of town; collected by Hancock. Test No. 43.

* Fluorspar Deposits of Southern Illinois, by H. Foster Bain; U. S. Geol. Surv. Bull. 255.

Crushed rock, Fulton, Ill., north edge of town, Sec. 28, T. 22 N., R. 11 E.; collected by Hancock. Test No. 44.

Crushed rock, Savanna, Ill., north edge of town, near C. B. & Q. tracks; collected by Hancock. Test No. 42.

Crushed rock, Mt. Carroll, southwest part of city; collected by Hancock. Test No. 46.

Crushed rock, Freeport, Ill., from city quarry; collected by Hancock. Test No. 41.

Galena limestone, southwest edge of Galena, in street; collected by Hancock. Test No. 45.

Crushed rock, Moline, Ill., The Cady Stone Quarry; collected by Hancock. Test No. 47.

Crushed rock, Moline, Ill., Cady Stone Quarry; collected by Hancock. Test No. 48.

Crushed rock, Moline, Ill., Cady Stone Quarry; collected by Hancock. Test No. 49.

Sandstone, Charleston, Ill., Oliver Quarry; collected by Bain. Test No. 23.

Crushed rock, Charleston, Ill.; collected by Bain. Test No. 25.

Limestone, Clark county, Stumps' Quarry, Wabash township; collected by Savage. Test No. 38.

No comprehensive study of highway material has been attempted. This is believed to be properly the work of the highway engineer, but it is proposed to utilize the survey corps as much as possible in the collection of samples and notes and outcrops. In this work Messrs. E. T. Hancock, F. W. DeWolf, T. E. Savage and F. B. Van Horn assisted in 1906.

Fertilizer Materials.—In certain portions of Illinois the soils, if a maximum crop is to be obtained, need treatment. Large quantities of limestone and phosphate of lime are annually imported and the amount which will be used seems likely to increase from year to year. Acting in coöperation with the Agricultural Experiment Station, a search has therefore been begun for local fertilizing materials. There is not much encouragement to hope for the finding of large bodies of phosphate rock, but in view of its importance to the State it has been thought that every effort should be made to locate such bodies. Accordingly samples of everything of possible value encountered in the course of the survey have been sent in and analyzed at the Experiment Station. The localities visited are indicated upon the accompanying map. So far nothing of any commercial importance has been found.

Limestone suitable for use upon certain soils in southeastern Illinois needing such material has been located and tested at a number of points, as is also shown on the accompanying map. The samples were collected by the Geological Survey and the analyses were made by the Agricultural Experiment Station. Mr. Van Horn has prepared a brief report upon the subject.

Building Stones.—The total stone output in 1905 amounted to over three and a half million dollars, divided as follows:

Limestone—	
Crushed rock	$1,904,350 00
Flux	581,497 00
Limestone for highways	533,917 00
Stone for lime making	395,164 00
Dimension stone	226,491 00
Sandstone	29,153 00
Total	$3,670,572 00

The most important increase in demand has been for crushed rock. While our supply of stone for dimension work is relatively limited, good rock for crushing exists largely distributed. So far there has been no opportunity to make a special study of the building stones of the State, a subject which urgently demands investigation.

Cement Resources.—Portland cement is manufactured in the vicinity of LaSalle and slag cement is made in the Chicago district. A new plant is being erected at Dixon and land is said to have been purchased near Port Byron for another. There are no cement factories in the central or southern part of the State. Since 1902 the cement industry of the State has been nearly stationary. In the meantime nine new plants have gone into operation in neighboring states, and a number of others are now building. The percentage of the output of the United States made from materials abundant in Illinois has jumped from 21.4 to 35.9, and the increased demand for cement has been enormous. Enough is known to indicate that there is an abundance of cement making materials, particularly in the southern part of the State. The large fuel supply available, the good transportation facilities enjoyed, and the fortunate geographic situation of Illinois entitle it to a greater share in the increased cement production. Analyses have been made of individual limestone and shales, but funds have been lacking for the thorough study of the whole subject which its importance demands.

Sand and Silica.—In the vicinity of Ottawa are deposits which furnish a large portion of the glass sand used in the United States. This sand, which belongs to the St. Peters sandstone, also enters into a number of other trades. The beds outcrop near Dixon to the north and again in Calhoun county. Other formations also yield sand suitable for making bottles, for building, molding and other purposes. In the aggregate the annual output amounts to about three-quarters of a million dollars. The deposits should be studied and tested in order to determine their extent and quality and with a view to finding new uses and markets for the material.

In southern Illinois, in Union and Alexander counties, there are beds of fine grained silica which are in demand in the wood polishing and other trades. Three mills are now engaged in preparing the silica for market and others are projected. The origin and extent of these beds are very imperfectly known, and it is not likely that all the uses to which it is adapted have been discovered. Preliminary to a thorough study of the entire subject samples have been taken and analyses are being made. It is hoped to follow these by further tests and surveys.

Ochre.—Colored clays of such quality that they may be used as pigments occur at different points in the State. The bulk of the colored clays fail in some particular or another, and are not adapted to such uses. From time to time samples sent into the office or collected by members of the survey have been tested, usually with negative results. One sample from Brown county appeared promising, and on being examined by one of the largest paint manufacturers in this country was found to be of value. The owner was put into communication with the paint makers and thus a market was found for his material. It is possible that other deposits exist, and it is hoped that they may be found and exploited.

General Stratigraphy.

A correct knowledge of the geology of the State as a whole is fundamental to any development of its mineral resources. The work on coal, clay, lead and zinc and other topics has, accordingly, been arranged to throw as much light as possible on the geology of the whole State. In order, however, to make the best progress, it has been found necessary to have some one whose major time should be devoted to this particular work. To Dr. Stuart Weller accordingly this duty has been assigned. He has visited each of the field parties, and has taken charge of the collections now being made. In addition, he has independently investigated certain areas adapted to throw light upon the general geology of the State. Some time was spent by him in southern Calhoun county. A brief report upon this area has been prepared and will be submitted for printing. Later Dr. Weller made a reconnaissance along the Mississippi river from St. Louis south. Early in the year he prepared a preliminary geological map of the State which was published in Bulletin 1 of the survey and has served a very useful purpose. He also furnished brief notes on the geological structure of the State for incorporation in the bulletin on petroleum and a revised copy of the geological map of the State for use in a second edition of Bulletin No. 1.

As a further preparation for detailed work, Mr. DeWolf was employed in May and June to make a general reconnaissance of southern Illinois, particularly of that portion in which Tertiary and Cretaceous strata outcrop. Mr. DeWolf is regularly employed by the U. S. Geological Survey and was detailed for this temporary service through the courtesy of the director of that organization. His trip brought to light many interesting facts regarding the area traversed, and will be of much assistance in future detailed surveys. An immediate return of the work is the report on the fire clays of that region appearing in the year book.

Arrangements have been made for collecting and recording the logs of deep wells as they are bored, and in this the active coöperation of municipalities, corporations and citizens is invited. In no other way than by the systematic collection and comparison of deep well records can the geology of much of the State be learned. A considerable number of records are now available, but many more are needed. A notable addition to the records is a diamond drill core from Delafield extending to a depth of 962 feet. This was courteously furnished to the survey by the Delafield Coal Company, and has been carefully examined by Mr. Jon A. Udden. If, when deep holes are to be put down, the survey is informed, it will furnish directions for the collection and preservation of samples, will examine the same, and will give such advice as to horizons as the circumstances permit. The preservation of such records is of great importance to the future development of artesian waters, oil, gas, coal and often minerals of the deeper rocks.

Mineral Statistics.

One of the most important aids to the economic development of an area is the publication of accurate statistics of production. In Illinois

very full and satisfactory statistics of the coal production are published annually by the Bureau of Labor Statistics. These figures are for the fiscal year, and there is no local agency collecting figures by the calendar year. Since this is the year used by most industries, it is important to have figures also from January to January. No one within the State collects statistics of output of the clay, stone, sand, oil and other mineral products than coal. The U. S. Geological Survey has for a number of years collected such statistics in Illinois as in other states, and arrangements have been made for coöperation with that organization in this work. Under this arrangement the correspondence is carried on as usual through the Washington office. The State Survey undertakes to assist in obtaining returns from delinquents and in revising and correcting the list of producers. Under this arrangement Mr. Van Horn spent some time in the work last winter, and prepared a separate circular giving the production in 1905. His totals are given below. If gas, silica, zinc and other minor materials were included the grand total would undoubtedly be considerably increased.

Total Value of Mineral Output in 1905.

Coal	$40,577,592 00
Clay	12,392,100 00
Limestone	3,644,499 00
Portland cement	1,741,150 00
Sand (estimated)	700,000 00
Natural and slag cement	166,550 00
Fluorspar	220,206 00
Petroleum	126,567 00
Lead ore	48,000 00
Mineral water	44,995 00
Sandstone	29,153 00
Total	$59,680,817 00

These figures include only the output of the mines and quarries of the State. If to them be added the output of smelters, which, however, work almost entirely on raw material from outside the State, the total would be raised to over $100,000,000.00.

Publications.

Three bulletins and one statistical circular have been printed and distributed. Manuscript for four additional bulletins are now in hand and being prepared for the printer. In addition, a nmber of reports are in a more or less advanced state of preparation. These are listed below.

Reports Printed.

Bulletin 1. The Geological Map of Illinois. By Stuart Weller. (24 pages and folded map.) The map, which is on the scale of two miles to the inch, shows the distribution of the different geological formations by colors and patterns. The shipping coal mines are also located, and

vertical sections illustrate the character of the different rocks in different parts of the State. There is an accompanying brief explanatory text. The map is based upon Worthen's map of 1875, but includes such corrections as were available at the beginning of the present survey. It makes no pretensions to great accuracy in detail, but has proven useful as a guide to further investigations. The value of such a map depends upon the fact that it shows the distribution of the natural economic products which exist within the crust of the earth in any region and of the rocks in which similar deposits are likely to occur. As the survey progresses, more accurate maps may be made, and their value will steadily increase.

Bulletin 2. The Petroleum Industry of Southeastern Illinois. By W. S. Blatchley; with sections by Messrs. Weller, Grout and Savage. (109 pages.) In this report the nature and the uses of petroleum, its origin, mode of occurrence and production are discussed. The petroleum bearing rocks of Illinois are briefly noted and the known oil occurrences within the State are systematically discussed. This report has been in great demand among intending investors in the region.

Bulletin 3. Composition and Character of Illinois Coals. By S. W. Parr; with chapters on the distribution of the "Coal Beds of the State" by A. Bement, and on the "Tests of Illinois Coals under Steam Boilers" by L. P. Breckenridge. (86 pages.)

In this report Professor Parr presents the results of a large number of analyses of Illinois coals and discusses their bearing on the classification of coals. Mr. Bement gives a map showing the general distribution of the principal coal beds, and Professor Breckenridge presents a tabular summary of the results of boiler tests of Illinois coals. In addition the figures of coal production for 1905 are given, and a map is printed showing graphically the relative intensity of production in different parts of the State.

Circular 1. The Mineral Production of Illinois in 1905. By F. B. Van Horn. Statistics of production of coal, clay, stone, etc., summarized by counties and subject.

Reports Ready for Printing.

Water Resources of the East St. Louis District. By Isaiah Bowman, assisted by Chester A. Reeds. A full discussion of the geologic, topographic and economic features of the water resources of this important district. Illustrations are being prepared.

Geographic Features of the Lake Michigan Shore North of Chicago. By W. W. Atwood and J. W. Goldthwait. This will be the first of the educational bulletins, and is designed to put in form useful to the school certain data regarding the present and past history of the lake. Illustrations are being prepared.

Year Book for 1906. This includes a number of short papers dealing with various phases of the survey work.

The Geological Map of Illinois. By Stuart Weller. This will be a revised edition of the map and text forming Bulletin 1, the edition of which is almost entirely exhausted. The map is now being engraved.

Reports in Preparation.

Report on the Paving Brick Clays of Illinois. This, which will summarize the bulk of the work done on the clays since the organization of the survey, will include chapters on the Geology of Clays, by Professor C. W. Rolfe; the Construction and Care of Brick Pavements, by Professor Ira O. Baker; The Testing of Paving Brick Clays and the Manufacture of Pavers, by R. C. Purdy. Certain of these chapters have been finished and circulated separately in a preliminary edition. It is expected that the entire report will be ready for the printer early in 1907.

A number of other reports are in less advanced state of preparation. These include a report upon the water resources of the State by Messrs. Bartow and Udden; a Bibliography of Illinois Geology, by Mr. Van Horn; a further report on the composition of coal by Professor Parr and his assistants, and numerous brief papers upon other phases of the work. Comprehensive reports on the various coal fields and on other areas are planned for, but cannot be prepared without much additional field work.

Bureau of Information.

One very important portion of the State Survey work is the answering of inquiries regarding the mineral resources of the State. These inquiries come from all classes and from all parts of the State as well as United States. Land owners, manufacturers, miners, mine operators, oil prospectors, lawyers, teachers, railway industrial agents and many others have availed themselves of the services of the survey in the last year.

The number of inquiries answered in the first twelve months of the survey's existence is tabulated below. They indicate sufficiently perhaps the wide range of inquiries, both geographically and by subject.

Requests for Information.

	Coal.	Oil.	Gas.	Clay.	Lead and Zinc.	Cement	Stone.	Water.	Maps.	Miscellaneous.
From in the State.....	97	231	77	24	12	5	12	14	130	130
From outside the State	77	108	138	13	2	.....	4	1	88	90
Total.....	174	339	205	37	14	5	16	15	218	220

While many of the inquiries require only simple answers, others entail considerable work and lengthy correspondence. The survey is glad at all times to answer such inquiries so far as data available will permit. Arrangements have been perfected for the free examination of specimens and materials so far as this does not involve extended laboratory investigations. No attempt has been made to furnish miscellaneous free assays or analyses, since the burden would rapidly be-

come disproportionate to the benefits to the State, and a single individual or firm could easily keep the whole force busy to the exclusion of any comprehensive investigations. There are, however, many inquiries which can be answered without such assay, and this is believed to be a proper and profitable task for the survey corps.

Expenditures.

The annual appropriation for the Geological Survey amounts to $25,000.00. Of thos sum $10,000.00 is alloted to coöperative topographic surveys and the remainder is devoted to geology. Below is given a tabular showing of the expenditures of the survey under the latter head. The expenditures for topography are reported separately.

Statement of expenditures of the State Geological Survey during the years 1905-1906 and 1906-1907, exclusive of topography.

Appropriation 1905–1906		$15,000 00
Expended for work on—		
Administration	$1,602 81	
Office expenses	1,042 80	
Coal investigations	2,698 97	
Clay investigations	1,979 91	
Educational Bulletins	327 65	
Water investigations	851 07	
Oil investigations	1,002 13	
Office furniture	2,207 23	
Minerial statistics	435 44	
Engraving map	906 00	
Paper and illustrations	644 74	
Revision of map	76 59	
Stratigraphy	119 15	
Miscellaneous	275 78	
		14,170 27
Balance on hand July 1, 1906		$829 73
Appropriation 1906–1907		$15,000 00
Expended for work on—		
Administration	337 41	
Office expenses	592 39	
Coal investigations	1,298 65	
Clay investigations	1,707 93	
Educational bulletins	271 18	
Water investigations	156 28	
East St. Louis surveys	428 34	
Springfield surveys	488 21	
Peoria Surveys	496 83	
General stratigraphy	851 55	
Reports	144 60	
Lead and zinc surveys	315 53	
Miscellaneous	58 20	
		7,147 10
Balance on hand November 1, 1906		$7,852 90

It will be noted that in the first four months of the present fiscal year half the funds for the year were expended. This is due to the fact that the heaviest expense falls in the summer months, when the largest force is at work in the field.

The expenditures for engraving and for other purposes connected with the reports were not orinigally allotted for, since section 6 of the Act establishing the survey provided that the printing of the reports should form a part of the State printing contract. Owing to the word-

ing of the law the Attorney General held that this did not cover the items here noted, and so, pending an amendment of the section, the payments have been made from the general funds of the survey.

Topographic Surveys.

Organization.

As contemplated by the law under which the Geological Survey was organized, the topographic work is being carried on in coöperation with the U. S. Geological Survey. A detailed report has been prepared by Mr. H. M. Wilson, Geographer in charge of the Eastern Division of Topography of the U. S. Geological Survey, who has been in general charge of this work. His report follows this and is illustrated by a map, plate 2, which shows even better than the report the excellent progress which has been made. Necessarily a considerable portion of the funds available has been spent in running lines of level and precise control in advance of the present surveys and in preparation for the work of succeeding years. It is planned for the present to confine the surveys mainly to the coal fields, since it is felt that it is there that such work will be of most immediate and practical value. It is there also that topographic surveys are most needed for geological work. It should not be inferred that exactly the same sort of a map will necessarily be made throughout the State. In certain areas maps of larger scale and with more detail will doubtless be called for, and in fact one such map already has been made in the lead and zinc region. In other portions of the State probably a less complete and therefore less expensive map will serve present purposes.

Recommendations.

In view of the needs of the work of the survey and the demands made upon it the following recommendations are made:

1. That the present annual appropriation for the general support of the survey, including topographic work, be raised from $25,000.00 to $50,000.00 per year. This is for the purpose of permitting investigations of cement materials, building stones, sands and other quarry products for which there have been no funds available so far, and for taking up certain other lines of investigation.

2. A portion of the increased appropriation is needed for an investigation of coal mining and accidents in coal mines, particularly those due to explosions. It is believed that the large loss of life and property annually resulting from explosions fully warrants a comprehensive investigation of their cause so that proper precautionary measures may be adopted. This should also cover such investigations as may be possible of waste in coal mining and the means of reducing it.

3. It is also very important that a survey and investigation of swamp and overflow lands in the State be made, together with a study of the measures necessary to their reclamation. Despite the efforts of local drainage boards, there remains considerable unreclaimed land

which is capable of becoming as productive as any in the State. Destructive floods in a single year wipe out property worth more than the whole cost of proper works to control certain rivers. Any works constructed to remedy these defects should be built according to plans taking into account the whole valley and the flood action of the whole river. Before such works are attempted, whether by State or local boards, the subject should be thoroughly investigated and the area of lands to be so benefited determined by accurate surveys at the same time that the proper methods of river control and costs are studied.

REPORT OF THE CO-OPERATIVE TOPOGRAPHIC SURVEY OF ILLINOIS.

(By H. M. WILSON.)

Contents.

Introduction.

Unlike many of its neighbors, the State of Illinois has never made an accurate and official topographic map of its area.. The best maps published are the general State geologic maps on a very small scale, showing some of the principal highways, most of the cities and villages and the drainage system of the State; the Postoffice Department of the Federal Government wall map, on the scale of about ten miles to one inch, showing positions of the principal postoffices; the land line map of the General Land Office of the government, showing system of sub-division of public lands; and county maps that have been published in a number of counties, showing roads, drainage system and other miscellaneous information. These county maps are on various scales, however, and have never been assembled in such form that a complete State map can be secured from them showing topography of the State in detail. For the Chicago Exposition of 1893 a large scale topographic map was prepared as a basis for a relief model which was exhibited in Chicago, but no map has been published from this manuscript copy, which latter was not accurate in detail. Meantime a number of the larger and wealthier states—Ohio, Kentucky, West Virginia, New York and some of the New England states—feeling the need of an accurate map depicting not only the general location of roads, of the drainage channels and of public land systems, but showing also in detail every bend on these roads, the houses along them, and especially the relief of the surface, the hills and the valleys with their elevations, have arranged with the United States Geological Survey to have made in coöperation with that survey such a topographic map of their areas. Under this system the states of Massachusetts, Connecticut, Rhode Island, New Jersey and West Virginia have already been completely mapped, and much progress toward the completion of such a map has been made in New York, Ohio, etc.

Appreciating the value and necessity of such a map as an aid to the rapid development of the economic resources of the State in minerals, including coal, oil, clay, lead, zinc and cement-making materials, and also as a basis for studies of the swamps and their drainage, the improvement of highways, and for studies of water supplies for cities, and as preliminary surveys for railways and trolley lines, the last session of the General Assembly provided for the making of a topographic map of Illinois through coöperation between the State Geological Survey and the United States Geological Survey. Correspondence was at once taken up by Governor Deneen, who secured the assistance of the United States Geological Survey on terms similar to those secured by other coöperating states, whereby the Federal Government agreed to expend as much money upon this work in the State of Illinois as the State should appropriate. The Federal Government assumed the responsibility for the making of the map through the medium of its existing organization. The State Survey reserved for the State of Illinois the right to say in what portions of the State the surveys were most urgently needed.

Legislative and Administrative.

Season of 1905-6.

In May, 1905, House Bill No. 63, of the General Assembly carried an amendment, which was adopted, whereby a State Geological Survey was established under the direction of a commission known as the State Geological Commission, and said commission was authorized to arrange with the director or representative of the United States Geological Survey in regard to coöperation between the United States Geological Survey and the State Geological Commission in the preparation and completion of a contour topographic survey and map or maps of the State of Illinois. The commission was authorized to spend a sum of not more than $10,000 in any one year on this work, providing this sum was met by an equal amount by the Federal Survey.

Agreement.—The following formal agreement was entered into in November, 1905, between the Governor of Illinois and the director of the United States Geological Survey, confirming a verbal agreement entered into in May, 1905, by which agreement provision was made for the execution of this topographic work:

Agreement between the State Geological Commission of the State of Illinois and the Director of the United States Geological Survey for the Execution of the Coöperative Topographic Survey of the State of Illinois as provided for in Act of Legislature of the State of Illinois, 1905.

(1) The preparation of the map shall be under the supervision of the director of the United States Geological Survey, who shall determine the methods of survey and map construction.

(2) The order in which, in point of priority, different parts of the State shall be surveyed shall be agreed upon in detail by the State Geological Commission of the State of Illinois and the director of the United States Geological Survey, but in case of failure to agree the order shall be determined by the State Geological Commission.

(3) The survey shall be executed in a manner sufficiently elaborate to prepare maps upon a scale of 1:62,500. This map shall exhibit the hydrography, hypsography and public culture, and all township and county boundary lines and extensive wooded areas in this State as existing on the ground at the time of the execution of these surveys: The location of all trails, by-roads, railroads, streams, canals, lakes, rivers, and shall show by contour lines the elevation and depression of the surface of the country.

(4) The hypsography shall be shown by contour lines with vertical intervals of 10 or 20 feet, depending upon the scale and relief of the country, and as may hereafter be agreed upon in detail.

(5) The heights of the important points shall be determined and furnished to the State Geological Commission of the State of Illinois.

(6) The outlines of wooded areas shall be represented upon the proofs of the engraved map to be furnished to the State Geological Commission of the State of Illinois.

(7) For convenience, the United States Geological Survey, shall, during the progress of the field work, pay the salaries of the permanent employés engaged thereon, while the traveling, subsistence and field expenses shall be paid for the same time by the State. For official work on the map the salaries shall be divided between the two agreeing parties in such way as to equalize expenses, providing that the total cost to the State of Illinois of the field and office work shall not be more than $10,000 from July 1st, 1905, to June 30, 1906, or for any subsequent fiscal year. And further provided, that the United States Geological Survey shall expend an equal amount upon the same work and during the same period of time.

(8) During the progress of the field and office work, free access to the records of the topographers shall be afforded the State Geological Commission

of the State of Illinois for examination and criticism, and, should the commission consider that the work is not being executed in accordance with this agreement, it may, on formal notice, terminate the same. This agreement may also be terminated by formal notice of either party thirty days prior to the beginning of the new fiscal year.

(9) The resulting reports shall fully recognize the coöperation of the State organization.

(10) All accounts and vouchers paid by the State Geological Commission under this agreement shall be subject to their auditing and approval.

(11) It is further agreed that, in view of the coöperation arrangements here entered into, the State Geological Commission of the State of Illinois shall be furnished with transfers, at the cost of printing, from the copper plates, for use in printing editions of said maps by the State.

(Signed) CHAS. D. WALCOTT,
Director U. S. Geological Survey.

Washington, D. C., November 20, 1905.

(Signed) CHARLES S. DENEEN,
Chairman State Geological Commission State of Illinois.

Springfield, Ill., November 17, 1905.

Plans, 1905-6. In correspondence of May, 1905, between President Edmund J. James, of the University of Illinois, one of the members of the State Geological Commission of Illinois, and Mr. H. M. Wilson, geographer in charge of the Eastern Division of Topography of the United States Geological Survey, detailed plans relative to localities of work, etc., were prepared for the approval of the Governor. It was decided to take up the mapping of the most available quadrangles, those which were already controlled by primary work; namely, Belleville, in Madison and St. Clair counties; Eldorado, in Gallatin, Hamilton, Saline and White counties; Mahomet, in Champaign and Piatt counties; Springfield, in Logan, Menard and Sangamon counties; New Haven (Ill., Ind. and Ky.) quadrangle, in Gallatin and White counties; and Urbana, in Champaign county. It was also planned to take up preliminary work with a view to completion the next season, on Breese, in Bond, Clinton, St. Clair and Madison counties; Carmi (Ill., Ind.) in White county; Havana, in Fulton and Mason counties; Petersburg, in Logan, Menard and Sangamon counties; Saidora, in Cass, Fulton, Mason and Schuyler counties; and Wheaton, in DuPage county. These plans were carried to completion, and the following preliminary report of the results of the coöperative topographic field work for the year 1905-6 was made by the director of the Geological Survey, to his Excellency, the Governor of Illinois, in December, 1905:

Preliminary Report—The following preliminary report was submitted at the close of the year:

COÖPERATIVE TOPOGRAPHIC REPORT, ILLINOIS, 1905-6.
WASHINGTON, D. C., Dec. 28, 1905.

His Excellency, the Governor of Illinois, Springfield, Illinois:

SIR—I have the honor to make the following preliminary report of the coöperative topographic survey of the State of Illinois for the year 1905-6:

ALLOTMENTS.

In Senate amendments of May, 1905, to House Bill No. 63, of the Forty-fourth General Assembly of the State of Illinois, the commissioners of the State Geological Survey were authorized to arrange with the director or other representative of the United States Geological Survey for a coöperative topographic survey of the State of Illinois.

In an agreement signed by you on November 17, 1905, on behalf of the State, and by me on November 20, 1905, on behalf of the Federal government, formally confirming our preliminary verbal agreement of May, provision was made for the execution of this work. In this it was provided that the total cost to the State of Illinois should not be more than $10,000.00 from July 1, 1905, to June 30, 1906, and that the United States Geological Survey should expend an equal amount upon the same work for the same period of time. On behalf of this survey I allotted an equal amount.

In correspondence of May, 1905, between President James of the University of Illinois, and Mr. H. M. Wilson, geographer, of this survey, supplemented by additional recommendations by yourself, plans have been made for surveys within the State and such plans have been carried to completion.

From the expenditure of the funds providing for this coöperation a complete and accurate map has been made for publication on the scale of 1:62,500, with contour intervals of 10 and 20 feet, of 1,347 square miles of the area of the State, which is represented on the following six sheets: namely, Belleville, in Madison and St. Clair counties; Eldorado, in Gallatin, Hamilton, Saline and White counties; Mahomet, in Champaign and Piatt counties; New Haven, (Ill., Ind., Ky.) in Gallatin and White counties; Springfield, in Logan and Menard and Sangamon counties; Urbana, in Champaign county. In addition, 83 square miles were mapped over the edges of these sheets, which will be incorporated in future map work.

Considerable preliminary work was accomplished on the following quadrangles: Breese, in Bond, Clinton, St. Clair and Madison counties; Carmi, (Ill., Ind.) in White county; Havana, in Fulton and Mason counties; Petersburg, in Logan, Menard and Sangamon counties; Saidora, in Cass, Fulton, Mason and Schuyler counties; Wheaton, in DuPage county. Of these the Breese and Wheaton quadrangles were about half surveyed.

During the season there were run on all of the above eleven sheets 3,740 miles of spirit levels, in the course of which 24,446 elevations and 101 permanent bench marks were established; there were run 6,221 linear miles of road traverse, every bend and every house being accurately located.

Two parties extended primary traverse over the counties of Champaign, Clinton, DuPage, Madison, Menard, St. Clair and Sangamon, resulting in the occupation of 1,441 stations and the running of 401 miles of traverse. One party extended precise levels over the counties of Champaign, DeWitt, McLean, Piatt and Tazewell, resulting in the running of 87 miles, in the course of which 20 elevations and 33 permanent bench marks were established.

I feel gratified in being able to report such excellent results in view of the late date at which the coöperation was perfected, and the subsequent shortness of the season. It offers assurance that even better progress may be looked for another season, when parties may be placed in the field at an earlier date and with a perfected organization.

Very respectfully,
(Signed) CHAS. D. WALCOTT,
Director.

SEASON OF 1906-07.

Agreement.—The coöperative agreement signed by the Governor of the State of Illinois and the director of the United States Geological Survey in November, 1905, was continued for the coöperative topographic survey of the State for the fiscal year ending June 30, 1907, in the following supplemental agreement:

Supplemental Agreement between the State Geological Commission of the State of Illinois and the Director of the United States Geological Survey for the continuation of the Coöperative Topographic Survey of the State of Illinois, for the fiscal year ending June 30, 1907.

In accordance with the provisions of an agreement between the above named parties, signed November, 1905, the terms of which are hereby extended for the continuation of this coöperative surveying, it is further agreed and understood that the State of Illinois shall expend for such coöperative surveys during the fiscal year ending June 30, 1907, a sum of not less than $10,000; *Provided*, that the United States Geological Survey shall expend for coöperative topographic surveys within the State an amount at least equal to the above.

CHARLES D. WALCOTT,
Director U. S. Geological Survey.

Washington, D. C., November 23, 1905.

C. S. DENEEN,
Chairman State Geological Commission, State of Illinois.

Plans 1906-07.—Plans were perfected for the execution of the coöperative topographic field work of 1906 between Mr. H. M. Wilson, Geographer of the United States Geological Survey, and Mr. H. F. Bain, Director of the State Geological Survey of Illinois. This correspondence is as follows:

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY.
WASHINGTON, D. C., March 9, 1906.

Subject—Plans, Illinois, 1906.

Dr. H. Foster Bain, Director State Geological Survey, Urbana, Illinois:

DEAR SIR—Replying to yours of March 6, recommending changes in plans for field season 1906 agreed upon by us Nov. 21, 1905:

The following is submitted in accordance with your suggestions:

Primary control, 10 sheets.

Precise levels, Champaign to Chicago or Olney.

Complete the following sheets:

1. Breese.
2. Wheaton.
3. Tallula.
4. Galatia.
5. Thompsonville.
6. Waukegan.

Preliminary mapping in following order:

7. Galena.
8. Apple River.
9. Edwardsville.
10. Alton.
11. Fithian.
12. Mulkeytown.
13. Vergennes.

Very respectfully,
(Signed) H. M. WILSON,
Geographer.

STATE OF ILLINOIS GEOLOGICAL SURVEY.
URBANA, ILL., March 12, 1906.

Mr. H. M. Wilson, Geographer U. S. Geological Survey, Washington, D. C.:

DEAR SIR—Acknowledging your letter of March 9th with reference to plans of Illinois in 1906, I find the suggestion and arrangement entirely satisfactory.

Very respectfully yours,
(Signed) H. FOSTER BAIN,
Director.

Preliminary Report.—As shown in the following preliminary report of progress submitted to the Governor by the Director of the Federal Survey, these plans were carried to completion by Dec. 1, 1906, so far as the funds available would permit.

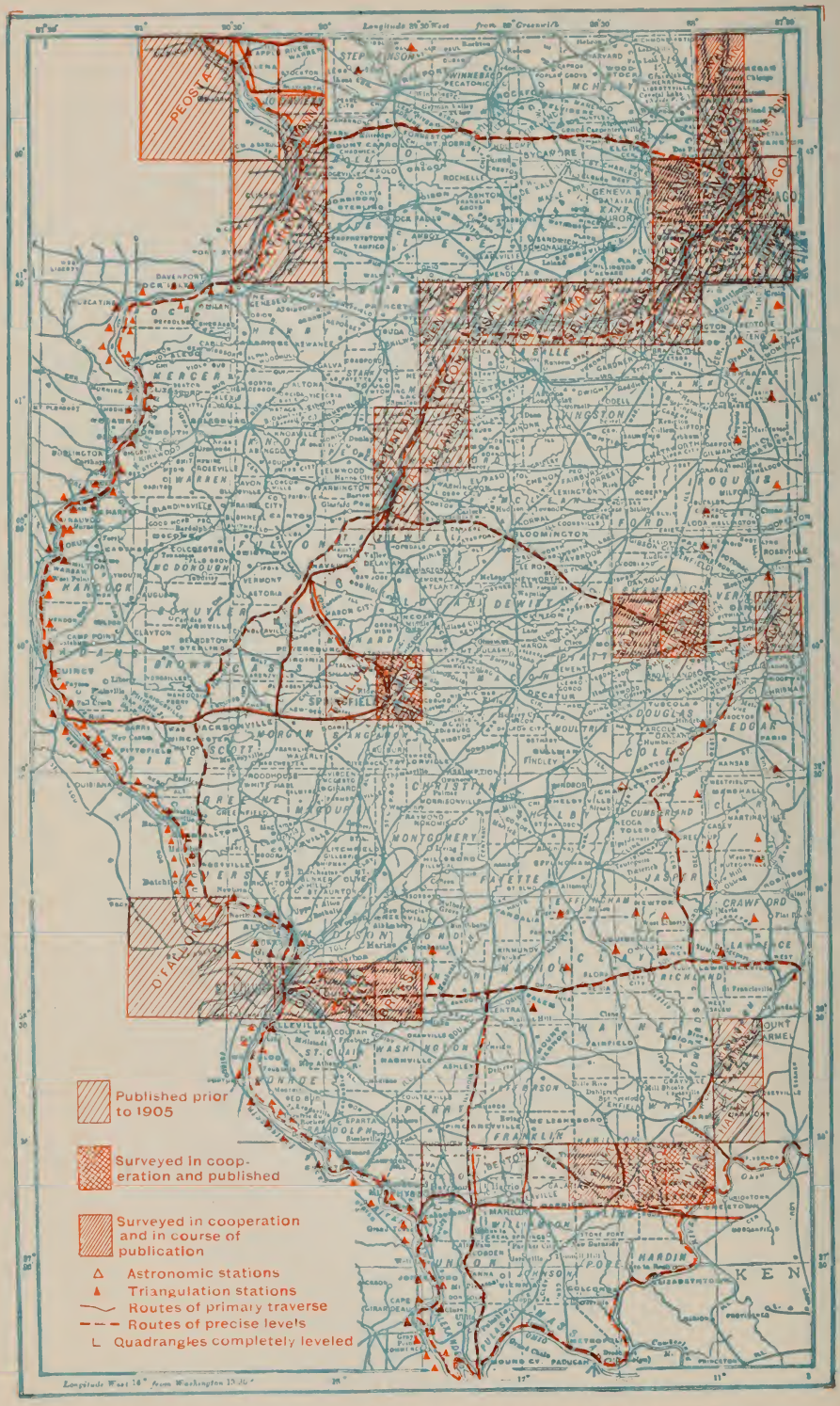
COÖPERATIVE TOPOGRAPHIC REPORT, ILLINOIS, 1906-7.
WASHINGTON, D. C., Dec. 15, 1906.

His Excellency, the Governor of Illinois, Springfield, Illinois:

SIR—I have the honor to make the following preliminary report of the coöperative topographic survey of the State of Illinois for the year 1906-7.

ALLOTMENTS.

At the beginning of the field season of 1906 there was a deficit from coöperation of the previous year of $778.70, from the allotment of the U. S. Government. In other words, it has overspent by this amount its allotment of $10,000.00. The State of Illinois balance was $513.34, and the new appro-



Map showing progress of coöperative topographic surveys.

priation beginning July 1, 1906, $10,000.00. The gross sum available therefore to surveys from that date was $19,734.64.

RESULTS.

Correspondence was immediately entered into between the director of the State Geological Survey, Dr. H. Foster Bain, and Mr. H. M. Wilson, geographer, of this survey, in which plans were perfected for the work to be executed during the year, and such plans have been carried to completion.

From the expenditure of the funds providing for this coöperation a complete and accurate map has been made for publication on the scale of 1:62,500, with contour intervals of 10 and 20 feet, of a land area of 884 square miles of the State, which is represented on the following four sheets, namely: Breese, in Bond, Clinton, Madison, and St. Clair counties; Galatia, in Franklin, Hamilton, Saline, and Williamson counties; Waukegan (Ill., Wis.), in Lake county; Wheaton in Cook and DuPage counties; Tallula, in Cass Menard, Morgan and Sangamon counties, was completed with the exception of 13 square miles, and this will be completed in the early spring with the balance of funds available. There were mapped on this sheet during the present season 211 square miles, 5 square miles having been mapped in 1905. In addition, on all of the above sheets there were mapped 90 square miles over the edges, which will be incorporated in future map work. Considerable preliminary work was accomplished on the following quadrangles, namely: Galena (Ill., Ia.), in JoDaviess county; Thompsonville, in Franklin and Williamson counties; Herrin, in Franklin, Jackson, Perry and Williamson counties.

During the season there were run on all of the above sheets 4,518 miles of spirit levels; also, 15,336 elevations, with 66 permanent bench marks established. There were run 3,227 miles of road traverse, upon which every bend and every house was accurately located.

One party extended primary traverse over portions of the counties of Franklin, Hamilton, Jackson, JoDaviess, Perry, Lake, Saline and Williamson. Office computations which will result from the work will furnish the geodetic positions of a great many points to which to tie future topographic and property surveys. This work resulted in the occupation of 1,671 stations, and the running of 398 miles of traverse. One party extended precise levels over portions of the counties of Coles, Cumberland, Douglas, Edgar, Franklin, Gallatin, Jasper, Richland, Saline and Vermilion. This work resulted in the running of 206 miles of double-line precise leveling, in the course of which 485 elevations and 76 permanent bench marks were established. These furnish exact heights through which to refer to mean sea level any spirit leveling which may be done hereafter by private or public organizations.

Owing to the late date at which it was possible to resume field work, namely, after the first week in July, because neither State nor Federal funds were available until the first of that month, the field season was unusually short. In spite of this I am glad to be able to report as good progress as could have been anticipated. Three of the atlas sheets mapped during the previous year, Urbana, New Haven and Eldorado, have been engraved by this survey at no expense to the State, and copies of these publications are sold at the nominal price of five cents per copy.

Very respectfully,

CHAS. D. WALCOTT,
Director.

EXPENDITURES.

For 1905 there was available $10,000.00 each of State and Federal funds. Of this all of the State funds except a balance of $513.34 had been expended to the close of the year ending July 30, 1906. All of the Federal funds had been expended and in addition an overdraft of Federal funds for the succeeding year was made to the extent of $778.70.

At the beginning of the second year of coöperation, July 1, 1906, there was available $10,000.00 each of State and Federal funds, and taken in conjunction with the balance and overdraft above enumerated, there remained an available fund amounting to $19,724.64. Of the funds for this year all of the State appropriation has been exhausted except a balance of $3.04. This, because under the terms of the agreement the State funds are to be used chiefly in meeting miscellaneous field expenditures. Of Federal funds there remained Dec. 1, a balance of $3,120.16. This balance has been reserved in accordance with the agreement in order to meet the permanent salaries of civil service employés who will be engaged in office throughout the winter in completing the drafting of the topographic maps. It is estimated that these salaries will amount to $2,800.00, and that about $200.00 additional will be needed to meet back bills coming due for transportation, expressage, etc., and any balance, possibly $100.00, which may remain in the early part of the field season will be devoted to completing the few square miles unmapped upon the Tallula quadrangle.

Resume of Results.

During the field seasons of 1905 and 1906 there were mapped 2,492 square miles, at a total expenditure for field and office work of $39,735.00. Including the cost of primary triangulation and precise levels and uncompleted mapping, this is at the rate of nearly $16.00 per square mile. This control includes a large amount of preliminary work toward future topographic surveying, there remaining about 1,200 square miles controlled by primary triangulation and by precise leveling through which to reduce spirit leveling to mean sea level.

Topographic surveying will have been completed on 11 sheets during the two years coöperation. The following tabular statement gives the names of these sheets, their areas within the State, scale, contour interval and year mapped:

Topographic Atlas Sheets Mapped in Co-operation.

Quadrangle.	Area Mapped.	Year.	Cont. Int.	Scale.
	Square Miles.	Original Survey	Feet.	
Belleville	233.28	1905	20	1.62500
Breese	233.28	1906	20	1.62500
Eldorado	235.66	1905	20	1.62500
Galatia	235.66	1906	20	1.62500
Mahomet	228.40	1905	20	1.62500
New Haven, (Ill., Ind., Ky.)	192.78	1905	20	1.62500
Springfield	229.22	1905	10	1.62500
Urbana	228.40	1905	10	1.62500
Waukegan (Ill., Wis.)	149.00	1906	10	1.62500
Wheaton	225.50	1906	10	1.62500
In process of mapping.				
Tallula	311.00			
Total (*)	2402.18			

(*) In addition 90 square miles were mapped over the edges of quadrangles in 1906.

Nature of Coöperation.

The coöperative topographical survey of the State has been vigorously prosecuted during the past two years in accordance with the joint agreements above cited. Under the terms of these agreements the execution of the work both in the field and office is under the immediate charge of the Federal Survey, which draws upon the large corps of trained topographers which has been created under it through the Federal Civil Service. It also provides the surveying instruments, drawing paper, stationery, etc., used in connection with this work, and the State Survey contributes no part toward these items of expenditure. The director of the State Geological Survey recommends all appointments to temporary positions, being those not governed by the Federal Civil Service; also the order in point of priority in which the different parts of the State shall be mapped, as he presumably knows best what are the needs of the State in this direction. Many of the citizens of the State who are competent engineers have found employment upon this work.

When the Legislature made its appropriation for beginning this work in 1905, the Federal Survey had made rough reconnaissance maps in many cases, and in a few cases more detailed and accurate topographic maps of a total area of 4,916.83 square miles of the State. These have been published by the government upon thirty-nine separate atlas sheets distributed throughout various parts of the State. It had unaided expended upon this work a sum roughly estimated to amount to $40,000 between the years 1887 and 1904 inclusive. A large portion of this work is on the scale of about two miles to one inch, with contours showing elevations for change of every fifty feet in altitude. Some of it is on the larger scale of one mile to one inch, with contour lines of twenty and ten feet interval. A considerable portion of this area was mapped before the Federal Survey began its more accurate work and is lacking in detail, is without representation of houses, and is devoid of accurate spirit leveling, so that the contouring and elevations upon it are not sufficiently reliable to afford a basis for exact engineering work.

The total area of Illinois is 56,650 square miles. There have been mapped in coöperation 2,492.18 square miles. Prior to coöperation, 4,916.83 square miles. There remain unmapped 49,241 square miles, though probably 3,000 square miles of the earlier reconnaissance work will ultimately have to be added to this area in the form of resurvey.

Objects and Recommendations.

As stated, the object of making a topographic survey of the State in such great detail as will permit of representing the map of the State on a scale of one mile to one inch, is primarily to serve as a basis for study of the structural and economic geology of the State, with a view to aiding in the development of its economic mineral resources. In 1905 Illinois ranked second among the states in quantity of coal produced, the amount being 38,434,363 short tons of a value of $40,577,592. It ranked well up in the production of building stone

and cement-making materials. It is believed that the output of many of the minerals found in the State may be increased through the medium of this survey. These maps have a high value in connection with all studies for drainage of swamp and overflowed lands. They show the positions of the swamps, the absolute heights of points upon them, and the relation of these in altitude to the stream channels through which they may be drained. They are of especial value to the State in connection with studies for the improvement of highways. They are needed in connection with the planning of public improvements, developing railways and trolley lines, etc.

At the close of December, 1906, 2,492 square miles have been mapped in coöperation. As shown above there remain unsurveyed in coöperation, or to be revised of the earlier work of the Federal Survey, about 50,000 square miles. In order that this work may be continued, now that it has been so auspiciously commenced, $10,000 should be appropriated for each of the years 1907 and 1908 for the execution of the topographic survey of the State.

From the total expenditure by the State and Federal Surveys, and the area mapped under it as above reported, it would seem that the average cost per square mile of the topographic mapping has been $16.00. Of this the State furnished one-half, or at the rate of $8.00 per square mile. It is possible that this rate may be reduced in the future, as a large amount of money was spent in the last year on precise leveling, which work has now been well extended over the State, and will be completed at little additional expense.

Organization and Reports.

The topographic surveying in Illinois is under the immediate direction of Mr. H. M. Wilson, geographer in charge of the eastern division of the United States Geological Survey. Under him, Mr. W. H. Herron, topographer, is in charge of the section which includes Illinois, and he has personal supervision of the topographic field work and is held responsible for the plan and organization in the State. Mr. S. S Gannett, geographer, has charge of the section of primary control and precise leveling and overlooks such work in Illinois. Under these men several topographers, named in the body of this report, had charge of field parties, assisted by temporary aids employed for the season only. All of the men excepting the temporary employés are U. S. Civil Service appointees who have passed a rigid engineering examination. The temporary employés are selected preferably from residents of the State and fill out applications accompanied by letters of recommendation showing their education, experience, and other qualifications for this special line of work. The field work of topographic surveying is further inspected by Mr. J. H. Renshawe, chief inspector of the U. S. Geological Survey, and by the director of the State Geological Survey. No charge whatever is made to the State for the ser-

vices of any of these expert division chiefs, which gets their supervisory advice free, excepting that Mr. Herron; the section chief submits accounts for the actual time he works for the State.

Weekly reports of progress are sent to the party chiefs, and monthly reports are submitted by the party chiefs to the section and to the division chief, and by the latter transmitted with a financial statement to the director of the State Geological Survey.

Fiscal System.

The salaries of the party chiefs are those at which they are appointed by the Honorable Secretary of the Interior as topographers in the Federal Survey. The salaries of the temporary aids are fixed in accordance with the qualifications shown in their applications, and by promotion subsequent to employment. All actual traveling expenses are refunded upon presentation of vouchers duly signed and sworn to, and per diem in lieu of subsistence is allowed, the same ranging from $1.50 to $2.25 a day, according to the location of the work and the nature of the duties assigned the employés. All vouchers are submited semi-monthly in duplicate to the division chief in Washington, who, after scrutinizing and approving them, transmits a portion to the Federal disbursing officers for payment and another portion through the director of the State Geological Survey to the State Auditor for payment. A monthly statement is certified to the director of the State Geological Survey itemizing the amount expended by the Federal Government. The conditions of the agreement are such that the State Survey expends the bulk of its funds during the summer season on actual field work and the Federal Government pays the permanent salaries. In consequence the Federal Government does not expend nearly so much as the State by the close of the season, having to reserve a sufficient sum to cover office salaries on drafting and computing.

Nature and Uses of Topographic Maps.

General Plan—The topographic maps made under this coöperative arrangement are drawn up in office in three colors and furnish exact copy for reproduction. The published maps are engraved in the office of the Federal Survey in Washington on three separate copper plates, on one of which is shown the drainage and water surfaces, on a second all roads, houses, names, and other cultural features, and on the third figures of elevation and shapes and heights of hills by contour lines The map is printed from transfers from these three copper plates to three lithographic stones, in blue, for the water features; black for the cultural features; and brown, for the topographic relief of the surface. The result is a very handsome and attractive and extremely legible map, the neat size of which is about 17½ inches high by 13 inches wide.

For purposes of convenient publication, and in order that the edges of adjoining sheets match and may be mounted together in larger groups, the whole area of the country is divided by latitudes and longitudes fifteen minutes each way to a map sheet, so that each map represents one quarter of a square degree, or an area in Illinois of approximately 225 square miles to an atlas sheet. To cover the entire State several hundred such atlas sheets will be required to make the final map which, extending from latitude 37° 00′ to latitude 42° 30′ will be 355 inches long north and south, and 240 inches long east and west. Upon this map when finally completed there will be located many thousands of geodetic positions, or an average of one to every twenty square miles, and a still greater number of permanent bench marks showing precise level elevations above sea, these averaging about two to each township. The latter will be of inestimable value as datum upon which to base all engineering work, and the former will serve as permanent bases for all future cadastral or property and political surveys.

Surveying in general may be divided into three classes:

1. Those made for general purposes, or information surveys, which may be exploratory, geodetic, geographic, topographic, geologic, etc.
2. Those made for jurisdictional purposes, or cadastral surveys, which define political boundaries and those of private property and determine the inclosed areas.
3. Those made for construction purposes, or engineering surveys, on which are based estimates of the cost of public and private works, such as canals, railways, water supplies, etc., and their construction and improvement.

The topographic survey, one of those in the first class, is made for military, industrial, and scientific purposes. The topographic map, made directly from nature by measurements and sketches on the ground, is the mother map from which all other are derived. It shows with accuracy all the drainage, relief, and cultural features which it is practicable to represent on the scales chosen.

The features exhibited of the maps are:

1. Hydrography, or water features, as ponds, streams, lakes, swamps, etc., which are printed in blue.
2. Hypsography, or relief of surface, as hill, valleys and plains which are printed in brown.
3. Culture, or features constructed by man, as cities, roads, villages, and the names and boundaries, which are printed in black.

This combination of colors renders these topographic maps readily legible. On the reverse of each sheet is a description of the mode of reading the map, and a legend, or series of conventional signs, indicating how the various facts shown on the map are represented. All these conventions are self-explanatory and are readily understood and interpreted by the layman, except, perhaps, the brown "contour" lines.

These contours are lines of equal elevation—lines along which the ground would be touched by the border of a water surface (of the ocean, for instance) if it were repeatedly raised by a given amount. Contour lines express three features of relief—(1) elevation, (2) horizontal form, and (3) grade or slope. To explain more clearly the manner in which the contours shown on the maps of the Geological Survey delineate height, form, and slope, the accompanying contour map (Fig. 1) has been prepared from the ideal view shown above it. It may be interpreted as follows:

1. A contour indicates a certain height above sea level. In this illustration the contour interval is 50 feet; therefore the contours are drawn at 50, 100, 150, and 200 feet, and so on, above mean sea level. Along the 250-foot contour lie all points of the surface 250 feet above sea; along the 200-foot contour, all points that are 200 feet above sea, and so on. In the space between

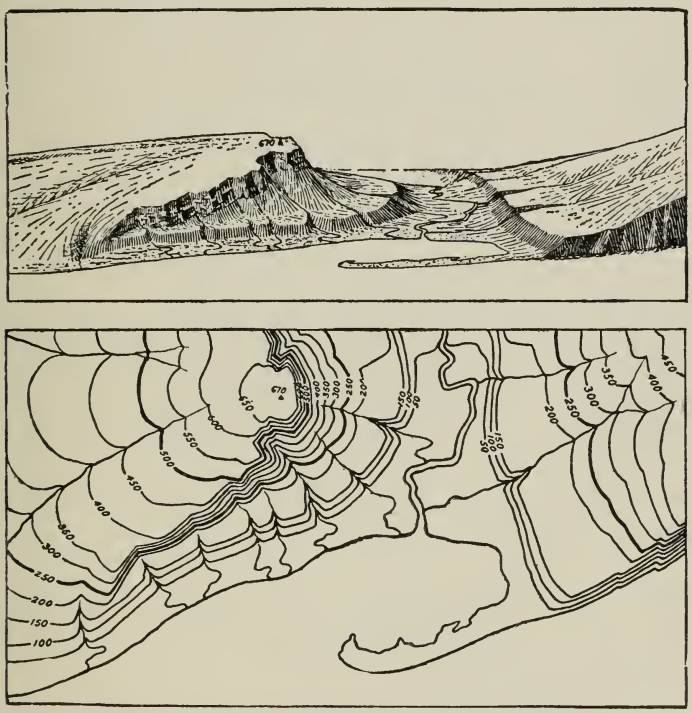


FIG. 1—Ideal view and corresponding contour map.

any two contours are found elevations above the lower and below the higher contour. Thus the contour at 150 feet falls just below the edge of the terrace, while that at 200 feet lies above the terrace; therefore all points on the terrace are shown to be more than 150 but less than 200 feet above sea. The summit of the higher hill is stated to be 670 feet above sea; accordingly the contour at 650 feet surrounds it. In this illustration all the contours are numbered, and those for 250 and 500 feet are accentuated by being made heavier. Usually it is not desirable to number all the contours, and then the

accentuating and numbering of certain of them—say, every fifth one—suffice, for the heights of others may be acertained by counting up or down from a numbered contour.

2. Contours define the horizontal forms of slopes. Since contours are continuous horizontal lines, they wind smoothly about smooth surfaces, recede into all reentrant angels of ravines, and project in passing about prominences. These relations of contour curves and angles to forms of the landscape can be traced in the map and view.

3. Contours show the approximate grade of any slope. The altitudinal space between two contours is the same, whether they lie along a cliff or on a gentle slope; but to rise a given height on a gentle slope, one must go farther than on a steep slope, and therefore contours are far apart on gentle slopes and near together on steep ones.

Publication.—While the Federal Survey coöperates with the State in the making of the field survey and the drafting of the resulting map, it undertakes alone the publication of the final results. In consequence, though the State contributes half toward the making of the survey, one of the most expensive features of the map making, the publication and distribution, is handled at no expense to the State. Meantime since the inception of coöperation the State has benefitted by marked improvements in the method and style of the published maps. Much greater detail and nicer representation is shown on the later maps than on the earlier ones. This includes chiefly, exactness in representing cuts and fills and other obstacles along railroads and highways; the position of the highest point on hill and mountain tops. Not only are all houses in cities and in the country shown, but school houses and churches are distinguished, as are cemeteries.

Scale and Contour Interval.—The scale selected for the coöperative maps is that adopted for the whole of the United States, which is being mapped upon two standard scales, one of about two miles to one inch, and the other of about one mile to one inch. This latter and larger scale is adopted for Illinois, the exact multiple being represented by the figures 1:62,500, which is an aliquot part of 1:1,000,00, the international scale adopted by all great organizations throughout the world, as well as by the Coast and Geodetic Survey and the War Department of the Federal Government. The actual field scale is 4,000 feet to 1 inch, which is reduced in publication. In regions of special importance, as about large cities, the field work of surveying is done on double this scale, or on the scale of 2,000 feet to 1 inch, though no arrangements for publishing on this larger scale have yet been made by the Federal Government.

The contour interval adopted is 10 or 20 feet according to the steepness and amount of relief or comparative flatness of the slopes. Which of these two contour intervals shall be used is agreed upon in detail each year by the coöperative officials; the maps about Urbana, where the country is quite level, having been mapped with the 10-foot interval, while the maps about Eldorado and Belleville, where the country is more deeply eroded being mapped on the 20-foot interval. The scale selected is so large that a distance of about 100 feet on the ground, can be represented on the map, thus permitting of the actual platting of every house and every bend of the road, etc. The contour interval is such that every change in slope and every difference in elevation amounting to 10 and 20 feet, can be accurately represented.

Woodland Areas.—Wooded areas are now indicated upon the co-öperative topographic maps in a faint green tint. The outlines of these wooded areas are mapped in the course of the field work at the same time with other features, but until recent years the information has been retained in manuscript, unpublished, because of the difficulty experienced in endeavoring to so represent the wooded areas as not to obscure other features. An inspection of the map now shows at once what is cleared land and what is wooded, and should the State at any time take up the study of its forest resources, the map will furnish to it, as they do to individuals and corporations, a satisfactory base map upon which to classify the kind and extent of different timbers. They also show the location of the timber lands in relation to routes of transportation as highways, streams, or rail, and the intervening slopes of hills or mountains over which the timber must be hauled to market.

Underwater Contours.—The contour system used in depicting the elevations of the relief surface and showing the shapes and the heights of the hills, their slopes, and the valley bottoms, is to be continued under water upon all lakes and other water bodies of any extent. Upon these lakes these contours are printed in firm blue lines, any point upon which represents the elevation above sea level, and by mere subtraction from the elevation shown for the surface of the water body the depth may be obtained.

Areas of Political Subdivisions.—The result of this topographic mapping is to show accurately for the first time the boundaries of all townships and counties so far as the data can be procured in the field and from county records. This survey is not warranted in investigating questions of disputed boundaries or of obscure boundaries. These are matters for determination by the courts. The boundaries as found and shown on the maps present clearly and accurately all questions connected with the townships and counties; shows in which township and county fall various roads, houses, etc., and furnish the data from which to make an exact measurement of the areas of these political subdivisions.

The system of symbols, and particularly the contour system by which elevations and slopes of these maps are shown, has been adopted by the Federal Survey after much careful thought.

Uses of the Maps.—It is evident from the foregoing that the uses of the maps are so varied as to furnish data touching nearly every public and private activity having to do with the surface of the land.

The maps are of practical value for planning engineering projects, improvement of highways, construction of electric and steam railways, and studies of the sewerage and water supply of the cities. They are of political value in connection with questions relating to legislative matters, as the subdivision of counties, the assignment of jurisdiction of State institutions, boundaries of towns, counties, and their relation to natural features. They are of administrative value in connection with questions of official control of public works, reservations, highways and jurisdictions of courts. They are of great value in connection with questions concerning the use of timber lands. They are of the highest importance to the military affairs of the State and Federal

Governments in planning encampments, marches, maneuvers, etc. They are of educational value by presenting an exact knowledge of the country, by serving teachers and pupils with studies of home geography, and the relations of hills, valleys and slopes to industrial activities and to water courses. They are of statistical value for the representation of facts relating to population, industries, products, etc.

A valuable aid, in connection with any inquiry into the improvement of the public highways, is furnished by the classification of the roads; as, first-class, or those having made surfaces of macadem, gravel or other permanent material; second-class, or ordinary public dirt roads; third-class, or private and farm roads; and fourth-class as trails or paths. A marked improvement is also shown in the character of the lettering and other finish of the engraving, making the maps more attractive and legible.

The State of Illinois has many thousands of acres of swamp lands, chiefly overflowed lands, in the bottoms of the Illinois, Ohio, Wabash, Mississippi and other rivers. Much of the area of these swamp lands have already been reclaimed under State laws. The larger of these swamp lands, those which are most expensive for drainage or protection, have not yet been brought under agriculture because of the magnitude of the engineering problems involved.

The coöperative topographic maps furnish the essential data preliminary to the study of drainage or protection of swamp lands on broad and comprehensive lines. They show the exact location of the submerged lands; the sources from which the waters which reach them are derived, with the area of watershed and the elevations of these submerged lands above the natural drainage channels, through which the waters may be passed. These maps will therefore greatly facilitate reclamation of many thousands of acres of these lands which now lie idle, but which when drained will add materially to the area of productive agricultural lands of the State.

Finally, they are of the highest economic importance as a means of showing location, extent and accessibility of lands, waters, forests, and mineral resources. They are indispensable to State and Federal bureaus, to owners, investors, and corporations in connection with inquiries into these matters. Their main importance, however, is as a basis upon which to study the geological formations and the relations of the various coal, oil and gas-bearing formations one to another, their depth below the surface and the probable extension of such resources into unexploited areas; also as a basis for soil surveys for the determination of the agricultural value and properties of the lands.

Progress of Topographic Surveys in Illinois Prior to Co-operation.

In 1887 the United States Geological Survey did its first work in topographic mapping in Illinois. This work was continued thereafter for several years with considerable energy, chiefly along the course of the Illinois river. This surveying was undertaken with a view to aiding the study of the Drainage Commission of Chicago in solving the problem with which it was charged, and included the making of a series of fifteen maps extending from Chicago via Joliet and Hennepin

to Peoria, and covering an area of approximately 3,700 square miles. Other topographic mapping was done in the neighborhood of East St Louis, and in the northwestern corner of the State in connection with studies of mineral resources in the neighborhood of Jo Daviess county. There were thus mapped in the seventeen years prior to coöperation 4,917 square miles without the assistance of the State, or at the average rate of nearly 300 square miles a year. It is evident that at this rate many years must pass before the survey of the State will be completed With coöperation appropriated for at the rate of $10,000 per annum, there have been mapped 2,492 square miles, or at the rate of 1,246 square miles per annum. At an increased rate of appropriation there would be an increased output. The topographic mapping done prior to coöperation is estimated to have averaged $8.00 per square mile. The total expenditure on this work by the Federal Government alone and unaided has therefore been about $39,336.

1887.—The first topographic surveying prosecuted by the United States Geological Survey in Illinois was in connection with the mapping of the Louisiana (Mo.-Ill.) sheet, in Pike county, for publication on the scale of 1:125,000, with 50-foot contour interval. The work was done by Mr. H. L. Baldwin, topographer.

1888.—During this year Mr. Baldwin completed the survey of the St. Louis (Mo.-Ill.) sheet, in Madison, St. Clair and Monroe counties, for publication on scale of 1:62,500, with 20-foot contour interval. This sheet was resurveyed in 1903 to bring the culture up to date of the Louisiana Purchase Exposition.

1889.—The Calumet (Ill.-Ind.) sheet, in Cook county, was mapped by Messrs. D. C. Harrison and R. C. McKinney. This sheet was published in 1901 after having been revised for cultural changes. The Chicago sheet, in Cook county, was mapped in this year and revised for publication in 1897 and 1899. The topographic field work was done by Messrs. D. C. Harrison, N. Tyler, jr., and R. C. McKinney, topographers, together with the Chicago Sanitary Commission. The Davenport (Ia.-Ill.) sheet, in Rock Island county, was mapped by Mr. W. J. Peters, topographer. It has since been reduced and forms part of the Rock Island (Ia.-Ill.) sheet, on scale of 1:125,000. The above work was all for publication on the scale of 1:62,500 with contour intervals of 5 and 20 feet respectively.

1890.—The Clinton (Ia.-Ill.) sheet, in Carroll and Whiteside counties, was mapped by Messrs. W. J. Peters and R. C. McKinney, topographers, and was revised in 1896. This was on the publication scale of 1:62,500, with a contour interval of 10 feet. The Desplaines sheet, in DuPage, Cook and Will counties, was completed by Messrs. D. C. Harrison and N. Tyler, jr., and the Chicago Sanitary Commission. It was revised in 1899 for publication on the scale of 1:62,500, with contour interval of 10 feet. Goose Lake (Ia.-Ill.) sheet, in Rock Island county, was mapped by Mr. W. J. Peters, topographer. It now forms a part of the Cordova (Ia.-Ill.) 1:125,000, sheet, though it was originally for publication on the 1:62,500 scale with contour interval of 20 feet. Joliet sheet, in Cook, DuPage and Will counties, was mapped by Mr. D. C. Harrison, topographer, on the 1:62,500 scale with contour interval of 10 feet. The Leclair (Ia.-Ill.) sheet, in Rock Island county,

was mapped by Mr. W. J. Peters, topographer. It also forms a part of the Cordova thirty-minute sheet, and is published on the 1:62,500 scale, with contour interval of 20 feet. The Marseilles sheet, in La-Salle, Grundy and Kendall counties, was completed by Mr. D. C. Harrison, for publication on the scale of 1:62,500, with contour interval of 10 feet. The Morris Sheet, in Kendall and Grundy counties, was also mapped by Mr. Harrison on the same scale and with the same contour interval. The Ottawa sheet, in LaSalle county, was mapped by Mr. Harrison on the same scale and with the same contour interval. The Peosta (Ia.-Ill.) sheet, in Jo Daviess county, was mapped by Mr. W. J. Peters, topographer, and was revised for publication in 1896. This was on the publication scale of 1:125,000, with a contour interval of 20 feet. The Riverside sheet, in Cook and DuPage counties, was mapped by Messrs. D. C. Harrison, N. Tyler, jr., and the Chicago Sanitary Commission, and was revised for publication in 1899, scale 1:62,500, contour interval 10 feet. Savanna (Ia.-Ill.) sheet, in Jo Daviess and Carroll counties, was mapped for publication on the scale of 1:62,500, with contour interval of 20 feet, by Mr. W. J. Peters, topographer. The Wilmington sheet, in Will county, was mapped by Mr. D. C. Harrison, for publication on the scale of 1:62,500, with a contour interval of 10 feet.

1891.—The Brodhead (Wis.-Ill.) sheet, in Winnebago and Stephenson counties, was mapped by Mr. Van H. Manning, topographer, for publication on the scale of 1:62,500, with a contour interval of 20 feet. The Dunlap sheet, in Stark, Marshall, Peoria, Tazewell and Woodford counties, was mapped by Mr. D. C. Harrison on the same scale with a contour interval of 10 feet, as was also Hennepin sheet, in Bureau and Putnam counties. Lacon sheet, in Bureau, Putnam and Marshall counties, was also mapped by Mr. Harrison, on the above scale, with a contour interval of 20 feet, as was the Metamora sheet, in Marshall, Woodford, Peoria and Tazewell counties, with a contour interval of 10 feet.

1896.—The Cordova (Ia.-Ill.) sheet, in Carroll, Henry, Rock Island and Whiteside counties, was produced by Messrs. W. J. Peters and R. C. McKinney, topographers, on the scale of 1:125,000, with a contour interval of 20 feet. This map work was a revision of the Clinton, Goose Lake, Leclaire, and Henry sheets, scale 1:62,500, which it replaced.

1897.—Lancaster (Wis.-Ia.-Ill.) sheet, in Jo Daviess county, was mapped by Mr. C. E. Cooke, topographer, for publication on scale of 1:125,000, with a contour interval of 20 feet. Highwood sheet, in Cook and Lake counties, was mapped by Mr. R. C. McKinney, topographer, for publication on the scale of 1:62,500, with a contour interval of 10 feet. Evanston sheet, in Cook county, was also mapped by Mr. McKinney, on the same scale and with the same contour interval. Danville (Ill.-Ind.) sheet, in Vermilion county, was mapped by Mr. W. J. Lloyd, topographer, on the above scale and with the same contour interval.

1898.—O'Fallon sheet, in Calhoun and Jersey counties, was mapped by Mr. Paul Holman, topographer, for publication on the scale of 1:125,000, with a contour interval of 50 feet. The Rock Island (Ia.-Ill.) sheet, scale 1:125,000, contour interval 20 feet, was mapped in 1889, and revised for publication in 1898. It is formed by reduction of four 15-minute sheets, of which Davenport, Ill., sheet is one.

1900.—Kahoka (Mo.-Ia.-Ill.), in Hancock and Adams counties, publication scale 1:125,000, contour interval 20 feet, was mapped by Mr. Paul Holman, topographer. Mineral Point (Wis.-Ill.) sheet, scale 1:125,000, contour interval 20 feet, in Jo Daviess county, was mapped by Mr. R. C. McKinney, topographer.

1901.—New Harmony (Ind.-Ill.) sheet, in White and Wabash counties, publication scale 1:62,500, contour interval 20 feet, was mapped by Mr. C. W. Goodlove, topographer. Princeton (Ind.-Ill.) sheet, in Wabash county, with above scale and contour interval, was also mapper by Mr. Goodlove. These sheets form by reduction, parts of the Patoka (Ind.-Ill.) thirty-minute sheet.

1902.—Mount Carmel (Ill.-Ind.) sheet, in Edwards, Wabash and White counties, scale 1:62,500, contour interval 20 feet, was mapped by Mr. C. W. Goodlove, topographer. It forms part of the Patoka (Ind.-Ill.) thirty-minute sheet, which latter was completed and published during the same year.

1903.—The St. Louis Special (Mo.-Ill.) sheet, was completed this year by Messrs. C. E. Cooke, W. O. Tufts, G. Young and the City of St. Louis, and was published on the scale of 1:24,000 with a contour interval of 20 feet. This sheet was reduced and included in the St. Louis double atlas sheet, scale 1:62,500 and contour interval 20 feet, a resurvey of the 1888 sheets.

1904.—Peoria sheet, in Tazewell, Peoria and Woodford counties, was mapped by Mr. C. E. Cooke, topographer, assisted by Mr. J. N. Williamson. This was on the publication scale of 1:62,500, with a contour interval of 10 feet.

The following list contains all topographic atlas sheets mapped by the United States Geological Survey outside of any coöperation with the State of Illinois. These sheets are arranged alphabetically by names. They show the exact area of any sheet within the State where the sheet overlaps one or more states. The total area mapped within the State is given.

The Geological Survey, in its measurement of areas, does not include large bodies of water bordering on political boundaries or the open ocean. The measurement closely follows the shore line, jumping from headland to headland across necks or straits less than 1,000 feet in width.

Quadrangles Mapped Prior to Co-operation.

QUADRANGLE.	Area Mapped	YEAR.		Cont. Int.	SCALE.
	Square miles	Original Survey.	Resurvey or Revision.	Feet.	
Brodhead (Wis.-Ill.)	0.99	1891	.....	20	1:62500
Calumet (Ill.-Ind.)	200.32	1889	1899	10	1:62500
Chicago	120.87	1889	1809	5	1:62500
Clinton (Ia.-Ill.) †	*143.13	1890	1896	20	1:62500
Cordova (Ia.-Ill.)†	492.81	1896	.....	20	1:125009
Danville (Ill.-Ind.)	200.12	1897	.....	10	1:62500
Davenport (Ia.-Ill.)§	*7.46	1889	.....	20	1:62500
Desplaines	223.36	1890	1899	10	1:62500
Dunlap	225.90	1891	.....	10	1:62500
Evanston	28.55	1897	.....	10	1:62500
Goose Lake (Ia.-Ill.)†	*3.30	1890	.....	20	1:62500
Hennepin	224.21	1891	.....	10	1:62500
Highwood	206.94	1897	.....	10	1:62500
Joliet	223.36	1890	.....	10	1:62500
Kahoka (Mo.-Ia.-Ill.)	3.11	1900	.....	20	1:125000
Lacon	225.06	1891	.....	20	1:62500
Lancaster (Wis.-Ia.-Ill.)	4.39	1898	.....	20	1:12500
LaSalle	224.21	1891	.....	10	1:62500
LeClaire (Ia.-Ill.)†	*104.58	1890	.....	20	1:62500
Louisiana (Mo.-Ill.)	11.49	1888	.....	50	1:125000
Marseilles	224.21	1890	.....	10	1:62500
Metamora	225.90	1891	.....	20	1:62500
Mineral Point (Wis.-Ill.)	10.46	1900	.....	20	1:125000
Morris	224.21	1890	.....	10	1:92500
Mount Carmel (Ill.-Ind.)‡	180.45	1902	.....	20	1:92500
New Harmony (Ind.-Ill.)‡	44.78	1901	.....	20	1:62500
O'Fallon (Mo.-Ill.)	71.74	1898	.....	50	1:125000
Ottawa	224.21	1890	.....	10	1:62500
Patoka (Ind.-Ill.)‡	*232.29	1902	.....	20	1:125000
Peoria	226.73	1904	.....	10	1:12500
Peosta (Ia.-Ill.)	23.90	1890	.....	20	1:125000
Princeton (Ind.-Ill.)†	7.06	1901	.....	20	1:62500
Riverside	222.50	1890	1899	10	1:62500
Rock Island (Ia.-Ill.)§	7.26	1889	1898	20	1:125000
Savanna (Ia.-Ill.)	177.00	1890	.....	20	4:62500
Ste. Genevieve (Mo.-Ill.)‖	2.00	1895	.....	50	1:125000
St. Louis (Mo.-Ill.) (double sheet)¶	194.43	1888	1903	20	1:62500
St. Louis Special (Mo.-Ill.)¶	.....	1903	.....	20	1:62500
Wilmington	224.21	1890	.....	10	1:62500
Total	*4,916.83	.....	.....	.....	.....

* Figures in italic are not included in total, as the sheets form parts of other sheets whose total areas are given.

† Clinton, Goose Lake, and LeClaire sheets, on scale of 1:62500 have been reduced, and form parts of Cordova sheet, on scale of 1:125000.

‡ Princeton, New Harmony, and Mount Carmel sheets, on scale of 1:62500, have been reduced, and form parts of Potoka sheet, on scale of 1:12500.

§ Davenport sheet, on scale of 1:62500, has been reduced and forms part of Rock Island sheet, on scale of 1:125000.

¶ St. Louis Special sheet is included within the St. Louis double sheet.

Detailed Report on Field Work.

ORGANIZATION AND PERSONELLE.

During the field season of 1905 three parties were engaged under the supervision of Mr. C. E. Cooke, chief of section, in the topographic mapping of twelve atlas sheets, portions of three of which lie in the adjoining states of Indiana and Kentucky, the area lying within the State of Kentucky having been mapped in coöperation with that state, and that lying within the state of Indiana having been mapped by the United States Geological Survey alone. The other two parties were

in charge of Messrs. Albert Pike and W. J. Lloyd, topographers. Six of the quadrangles surveyed were completely mapped during the season. Primary control was extended under the supervision of Mr. S. S Gannett, geographer, by two parties under Messrs. E. L. McNair and J. R. Ellis, assistant topographers. One line of precise levels was run by Mr. McNair.

During the field season of 1906 Mr. W. H. Herron, topographer, was placed in supervisory charge of the section which includes Illinois, and under him three parties were maintained throughout the season under Messrs. W. J. Lloyd, topographer; C. L. Sadler, assistant topographer, and J. G. Staack, topographic aid. Towards the latter end of the season two parties under Messrs. A. T. Fowler, assistant topographer, and C. Hartmann, topographic aid, were added to these to aid in completion of work planned. During this season the topographic mapping of four atlas sheets was completed and a fifth will be completed in the early spring. Preliminary work toward future mapping was in progress on three others.

Primary control was continued under the general supervision of Mr S. S. Gannett, geographer in charge of the section of triangulation and computing of the Federal Survey. This work was done by a party in charge of Mr. L. E. Tucker, topographic aid. Two lines of precise levels were run by Mr. T. A. Green, field assistant.

Summary of Results.

The following are tabular statements of the results of the field work of the seasons of 1905 and 1906:

Summary Statement of Field Work, 1905.

STATE.	Counties.	Sheets.	Topographers.	Days of work—Number	Total area mapped—square miles	LEVELS. BMs—Total number.	LEVELS. Spirit levels—Miles.	LEVELS. Total elevations—Number.	Total traverse—Miles
Illinois, Indiana, Kentucky	Madison, St. Clair	Belleville	C. E. Cooke, L. S. Smith, W. J. Lloyd	39	233	12	727	3,776	910
	Gallatin, Hamilton, Saline, White	Eldorado	C. E. Cooke, W. J. Lloyd.	42	236	12	578	4,247	894
	Champaign, Piatt	Mahomet	C. E. Cooke, A. Pike	33	228	12	582	4,094	576
	Gallatin, White	New Haven	C. E. Cooke, W. J. Lloyd, L. S. Smith	37	193	13	419	2,013	734
	Logan, Menard, Sangamon	Springfield	C. E. Cooke, A. Pike, F. T. Fitch	45	229	11	578	5,185	1,082
	Champaign	Urbana	A. Pike	29	228	14	685	4,795	698
	Total new survey completed in field			225	*1,347	74	3,569	24,110	4,894
Illinois, Indiana	Bond, Clinton, St. Clair, Madison.	Breese	W. J. Lloyd			10	58	206	578
	White	Carmi	W. J. Lloyd				39	47	
	Fulton, Mason	Havana	A. Pike			1	6	19	
	Logan, Menard, Sangamon	Petersburg	A. Pike			3	14	39	
	Cass, Fulton, Mason, Schuyler	Saidora	A. Pike			1	7	19	
	DuPage	Wheaton	C. E. Cooke, A. Pike			12	47	6	751
	Total new survey uncompleted in field					27	171	336	1,329

PRIMARY TRAVERSE.

Counties.	Topographers.	Days of work—Number.	Stations.	Azimuths.	Permanent marks.	Total traverse.
Champaign, Clinton, DuPage, Madison, Menard, St.Clair, Sangamon	J. R. Ellis, E. L. McNair	52	1411	36	22	402

PRECISE LEVELS.

Counties.	Topographer.	Days of work—Number.	Bench Marks	Miles.	Elevations.
Champaign, DeWitt, McLean, Piatt, Tazewell	E. L. McNair	27	33	87	20

*Eighty-three square miles not included in this area were mapped over the edges of the above sheets.

Summary Statement of Field Work, 1906.

STATE.	Counties.	Sheets.	Topographers.	Days of work—Number	Total area mapped—Square miles	LEVELS. BMS—Total number.	LEVELS. Spirit levels—Miles	LEVELS. Total elevations—Number	Total traverse—Miles	Total cost—(Field only)
	Bond, Clinton, Madison, St. Clair	Breese	C. L. Sadler	49	233	.....	345	2,506	20	$1,154 16
	Franklin, Hamilton, Saline, Williamson	Galatia	C. L. Sadler, C. Hartmann	69	236	12	559	2,916	887	2,921 35
	Lake	Waukegan	W. J. Lloyd, J. G. Staack	39	149	21	390	2,364	436	1,403 71
	Cook, DuPage	Wheaton	W. J. Lloyd, J. G. Staack	73	226	.....	596	3,513	.....	1,776 23
	Totals, completed in field	.....	.....	230	844	33	7,890	11,299	1,343	$7.255 45
Illinois, Iowa	JoDaviess	Galena	W. J. Lloyd	.....	.....	.....	30	167	104	$ 389 38
	Cass, Menard, Morgan, Sangamon	Tallula	W. J. Lloyd, A. T. Fowler	56	211	22	526	3,759	634	2,473 02
	Franklin, Williamson	Thomps'nville	C. L. Sadler	.....	.....	11	18	111	984	784 47
	Franklin, Jackson, Perry, Williamson	Herrin	C. L. Sadler	.....	.....	.....	.....	.....	162	220 04
	Totals, uncompleted in field	.....	.....	56	211	33	574	4,037	1 884	$3,866 91
	.....	East St. Louis	C. L. Sadler	5	.....	.....	.....	.....	.....	$ 84 53
	Cook, Lake	Highwood	W. J. Lloyd, J. G. Staack	.....	.....	.....	54	.....	.....	133 67
	Totals, revision	.....	.....	5	.....	.....	54	.....	.....	$218 20

PRIMARY TRAVERSE.

Counties.	Topographer.	Days of work—Number.	Total square miles	Stations.	Azimuths.	BMs—Total.	Total Cost.
Franklin, Hamilton, Jackson, JoDaviess, Perry, Lake, Saline, Williamson	L. E. Tucker.....	75	398	1671	51	40	$2,089 89

PRECISE LEVELS.

Counties.	Topographer.	Days of work—Number.	Miles.	B. M.	Elrus.	Total Cost.
Coles, Cumberland. Douglas, Edgar, Franklin, Gallatin, Jasper, Richland, Saline, Vermilion.....	T. A. Green.....	83	206	76	435	$2,133 98

Spirit Leveling.

METHODS.

The elevations shown on the topographic maps are determined from accurate spirit leveling executed in three orders: First, precise leveling, whereby levels are brought hundreds of miles from mean sea level to different parts of the State, and furnish the fundamental bases to which further leveling is referred. This leveling is of the highest order. Some of it has already been executed by the Coast and Geodetic Survey, and recently this coöperative survey has run many lines of such leveling. Second, primary leveling is run in connection with the topographic mapping and consists of a high order of engineering levels, such as are run on railways or in cities. Lines of these levels are run with such frequency as to permit of the placing of two permanent bench marks in each township. Third, based on the above, secondary leveling or flying leveling is run with less accuracy but yet within limits of about one foot, so as to procure elevations upon which to base the contour sketching, these lines of levels running practically into every section of one mile square within the area surveyed. In appendix attached hereto are printed instructions governing this work, as is a list giving elevations determined by leveling both prior to and since coöperation.

During 1905 five parties were engaged in the running of spirit levels over the areas under survey, and in 1906 five parties were engaged in leveling. This work was for the purpose of determining elevations and establishing bench marks upon which to base the contour sketching of the areas mapped. During the field season of 1905 there were run 3,740 miles of spirit levels, and 101 permanent bench marks of metal were established. In 1906 there were run 4,518 miles of spirit levels, and sixty-six permanent bench marks were established. Appended hereto are descriptions of such bench marks as were established during the field season of 1905, all of the precise leveling for 1906 and a little of the primary leveling for the latter year; also of levels run prior to coöperation.

ELEVATIONS DETERMINED, 1896-1906.

These results are computed on a common mean sea level datum with the exception that no adjustment has yet been made of the results of precise leveling of 1906 to take account of apparent closure errors at Shawneetown and Fairmount Junction. The results of precise leveling are therefore not finally reduced, but it has been planned to obtain additional checks in 1907 by precise leveling and an adjustment will then be made. The connection with mean sea level is obtained by the adjustment made in 1903 by the U. S. Coast and Geodetic Survey of a great net of precise levels which combines work of various organizations and covers the eastern half of the United States. The precise level lines within or along the borders of this State are the Mississippi River Commission line and the lines Savanna to Chicago, Grafton to Chicago and Ohio River Survey by army engineers (the last two not

yet published), the lines Vincennes, Indiana, to St. Louis, Mo., and Cairo to Odin, by the Coast Survey and lines herein reported by the U. S. Geological Survey.

All results of spirit leveling in this State previously published by the U. S. Geological Survey, and all later work are included in this report, rearranged by quadrangles and separated into two parts, results prior to and those under coöperation. Descriptions and elevations of bench marks are given in fifty counties.

The filed work previous to 1903 was done under the general direction of Mr. J. H. Renshawe, geographer, and the later work under Mr. H. M. Wilson, geographer. The work in the State was supervised in 1905, by Mr. C. E. Cooke, topographer, chief of section. The office work of computation, adjustment and preparation of lists was done by Messrs. L. C. Fletcher and D. H. Baldwin, topographers, under the supervision of Mr. S. S. Gannett, geographer in charge of the Triangulation and Computing Section of the Geological Survey.

The elevations are arranged according to the degree of accuracy of their determination, precise and primary. The precise leveling in this State consists of lines run in both forward and backward direction, using high grade instruments, special precautions being taken in observations and reduction, with small allowable limits of divergence to insure the lines to be continuously good throughout. The primary leveling consists of ordinary wye leveling, precautions being taken against only the principal errors; these lines are principally run in circuits of single lines which are required to close within a less severe limit of error. The allowable limit of divergence adopted by the U. S. Geological Survey on all recent precise work is represented in feet by $0.017\sqrt{D}$ in which D represents distance in miles between bench marks and the limit for primary work is represented in feet by $0.05\sqrt{D}$, D in the latter case representing the circuit distance in miles.

The standard bench marks are of the two following general forms. The first, a circular bronze or aluminum tablet 3.5 inches in diameter and 0.25 inch thick, appropriately lettered, having a 3 inch stem cemented into a drill hole, generally in vertical walls of public buildings, bridge abutments or other substantial masonry structure. The second, a form employed where masonry or rock is not accessible, consists of a hollow wrought iron pipe post 3.5 inches outer diameter and 4 feet in length after being split at bottom and expanded to 10 inches at base so as to prevent both the easy subsidence of the post and its being maliciously pulled out of the ground. The iron is heavily coated with asphalt, and over the top of the post is riveted a bronze tablet similar to that described above.

The numbers stamped upon the bench marks as described in the following lists represent the elevations to the nearest foot above mean sea level, as determined by unadjusted levels in the field. They have been subjected to changes resulting from adjustments necessary to close circuits and to those resulting from reduction to mean sea level through readjustment of the precise level net of the United States. In some cases the finally accepted elevations as printed herein differ from those submitted as bench mark numbers by one or two feet. This method

of numbering bench marks has been adopted where many levelmen are working in the same area at the same time, as less liable to lead to confusion in identification of bench marks than any attempts at serial numbering, and because the bench mark number at the same time gives an approximate statement of the elevation. It is assumed that engineers and others finding these bench marks so stamped in the field will communicate with the director of the U. S. Geological Survey in order to obtain the accepted elevation to hundredths or thousandths of a foot.

Any person finding bench marks in the following lists mutilated or destroyed will confer a favor by notifying the Director, United States Geological Survey, Washington, D. C., or the Director, State Geological Survey, Urbana, Illinois.

PRECISE LEVELING.

List.	Quadrangles.	Counties.
1	Danvers, Danville, Farmer City, Leroy, Mackinaw, Monticello, Mahomet, Peoria and Urbana	Champaign, DeWitt, McLean, Piatt, Tazewell and Vermilion
2	Olney, Newton, Greenup, Bradbury, Mattoon, Oakland, Kansas, Sidell and Fithian	Coles, Cumberland, Douglas, Jasper and Richland
3	DuQuoin, Gallatia, Mulkeytown, Shawneetown and Thompsonville	Franklin, Gallatin, Perry and Saline.

PRIMARY LEVELING.

4	Evanston, Highwood and Waukegan	Cook and Lake
5	Wheaton	DuPage
6	Havana, Petersburg and Springfield	Mason, Menard, Logan and Sangamon
6a	Peoria	Peoria and Tazewell
7	Mahomet and Urbana	Champaign and Piatt
8	Belleville and Breese	Bond, Madison and St. Clair
9	Carmi, Eldorado, Enfield and New Haven	Gallatin, Hamilton, Saline and White

FIELD WORK OF 1906 NOT YET PREPARED FOR PUBLICATION.

Tallula	Sangamon
Mulkeytown	Franklin, Williamson
Thompsonville	
Gallatia	Hamilton
Eldorado	Saline

FIELD WORK OF 1906 NOT YET COMPLETED.

Galena	Jo Daviess
Apple River	

PRECISE LEVELING.

Danvers, Danville, Farmer City, Fithian, Leroy, Mackinaw, Monticello, Mahomet, Peoria and Urbana	Champaign, DeWitt, McLean, Piatt, Tazewell and Vermilion

The following are unadjusted results of precise levels run in 1905-6; in 1905 from the U. S. A. engineers bench marks at Pekin, over the C. C. C. & St. L. R. R. to Champaign, and continued in 1906 over the Wabash Railroad to Catlin.

The initial bench mark at Pekin is described as follows: Copper bolt sunk in top of traction bridge over the Illinois river about 12 feet north of center of track. The elevation of which is accepted as 455.364 feet as obtained by an adjustment of the army engineers' line between Grafton and Chicago. The methods, kind of instruments and limit of error used are those now adopted by the U. S. Coast and Geodetic Survey. On all sections upon which the forward and backward measures in milimeters differed more than $4.0\sqrt{K}$ (in which K is the distance between bench marks in kilometers), both forward and backward measures were repeated until a pair run in opposite direction came within limits, and all other requirements necessary to obtain accurate results were closely adhered to. In 1905 self reading rods were used, 3.2 meters in length, graduated to centimeters and reading to milimeters by estimation, but in the work of 1906 self reading rods of the same length were used but graduated to hundredths of a yard and reading by estimation to thousandths, computations being made in feet. The equivalent limit of error expressed in feet being $.017\sqrt{D}$ (where D is the distance in miles between bench marks).

Connection made at Fairmount Junction with precise level line run from Olney shows elevations by the line from Pekin to be 0.740 foot higher than as determined from Olney.

The leveling of 1905 was done by Mr. E. L. McNair, topographer in charge, and that of 1906 by Mr. T. A. Green, levelman, under the direction of Mr. S. S. Gannett, geographer.

The standard bench marks of the 1906 line are stamped with figures of elevation and year, but those set on the 1905 portion have not yet been stamped.

Precise Leveling.

PEKIN, VIA C. C. C. & ST. L. RAILWAY, TO CHAMPAIGN.

PEORIA QUADRANGLE.	Feet.
Pekin, in water table on east side of county clerk's office, copper bolt..	479.034
Pekin, in the water table on east side of county clerk's office, bronze tablet stamped	479.023
Pekin, in top of east abutment of traction line bridge across the Illinois river, 12 feet north of center of track, copper bolt, U. S. Army Engineers' bench mark	455.364
Pekin, in front of Big Four station, top of rail.....	467.1
Leslie, 1 mile west of; 6 miles east of Pekin, 15 rails east of mile post marked P15, 15 feet from center of Peoria and Eastern Railway track, in coping stone of concrete culvert, aluminum tablet stamped	681.922
MACKINAW QUADRANGLE.	
Tremont, in front of station; top of rail.....	643.8
Tremont, at west end of concrete platform of station, 25 feet southeast of street crossing, iron post stamped.....	643.367
Menert, 0.33 miles west of; in top of north end of east abutment of plate girder bridge over Mud creek, aluminum tablet stamped.....	575.578

	Feet.
Menert, in front of station, top of rail	595.3
Menert, 0.67 miles east of; on top and on south end of west abutment of a through bridge over Mackinaw river, 6 feet below top of rail, 3.5 feet from center of track, and midway between south shoeplate and south floor beam in first panel from west, aluminum tablet stamped	583.077
Mackinaw, 175 feet west of station; in top of first cap in east pier of first row of piers to railroad water tank, aluminum tablet stamped.	646.182
Mackinaw, in front of station; top of rail	645.4
Lilly, in top of southwest corner of west end of concrete platform of railroad station, 5 feet north of center of track, aluminum tablet stamped	803.211
Lilly, in front of station; top of rail	802.3

DANVERS QUADRANGLE.

Woodruff, 900 feet west of coaling sheds, 30 feet south of center of track, on right of way line in front of house of N. C. Osman, iron post stamped	840.142
Danvers, in top of southwest corner of west end of concrete platform of station, about 120 feet south of station; aluminum tablet stamped	809.212
Danvers, in front of station, on top of rail	809.1
Danvers, 4.5 miles east of, in coping of east wall of a wagon pass under railroad, 6 feet north of center of track, aluminum tablet stamped	754.892
Twin Grove, in front of station, top of rail	817.2
Twin Grove, at north end of station platform, due south of elevator owned by F. Supple, 10 feet south of track, iron post stamped	816.364
Bloomington, 0.75 miles west of, Alton and "Big Four" junction in south side of west abutment of a plate girder bridge across a creek used as an open sewer for the city, 6 feet below top of rail and 15 feet from center of track, aluminum tablet stamped	746.227

LEROY QUADRANGLE.

Bloomington, C. & A. junction Kansas City Division	775.2
Bloomington, in front of station; top of rail	789.2
Bloomington, in north pier of the water tank about 350 feet east of passenger station and on south track, aluminum tablet stamped	793.894

(*Spur Line from Above B. M.*)

Bloomington, in southwest corner of courthouse, about 2 feet above ground and in face of wall, aluminum tablet stamped	829.744
Bloomington, 1 mile east of; Illinois Central Railway crossing	857.6
Gillum, 2 miles west of; in top of parapet wall of, on south side of a concrete arch across a draw on the Big Four R. R., arch is No. 300-88, 20 feet from center of track, aluminum tablet stamped	832.781
Gillum, 75 feet west of station; 20 feet from center of track, on south side and 1.75 foot below rail, iron post stampel	820.361
Gillum station; top of rail	822.0
Downs, 360 feet east of station; 15 feet south of center of track, 10 feet northwest of section car house, iron post stamped	794.200
Downs, in front of station; top of rail	796.2
Ford Woods, 0.67 mile west of; in coping stone on north side of a stone arch on railroad, No. of arch 293.94, 12 feet from center of track, aluminum tablet stamped	791.284
Ford Woods station, in front of, top of rail	802.9
LeRoy, 330 feet east of station; 20 feet south of center of track, at intersection of right of way line and street line, iron post stamped	779.848
LeRoy, in front of station; top of rail	780.8
Empire, 130 feet west of station; 15 feet north of center of track, and 15 feet east of switch stand at siding, iron post stamped	755.525

	Feet.
Empire, in front of station; top of rail	756.6
Farmer City, 1 mile west of; in top of, on west side of abutment of a small I beam bridge on railroad, 10 feet from center of track, aluminum tablet stamped	730.664
Farmer City, at Illinois Central crossing, top of rail	732.2
Farmer City, "Big Four Ry." B. M. (R. R. elevation 723.500)	733.805
Farmer City, 375 feet east of junction of "Big Four" and Illinois Central Rys., 18 feet south of center of track and 65 feet south of where first street east of P. & E. R. R. station crosses tracks, iron post stamped	732.456

MONTICELLO QUADRANGLE.

Harris, 60 feet west of station; 16 feet north of center of tracks; iron post stamped	721.579
Harris, in front of station; top of rail	722.7
Mansfield, 270 feet east of Wabash and "Big Four" R. R. crossing, 18 feet south of the center of Big Four, iron post stamped	727.234
Mansfield, station, top of rail at Wabash R. R. crossing	729.6

MAHOMET QUADRANGLE.

Mansfield, 3.5 miles east of; in south end of the west abutment of a plate girder bridge on the Big Four R. R., bridge No. 270-40, aluminum tablet stamped	721.609
Mahomet, 230 feet west of station; 15 feet north from center of track, iron post stamped	712.064
Mahomet, in front of station; top of rail	712.3
Mahomet, 2 miles west of; in top of south side of a stone culvert on P. & E. R. R., 10 feet from center of tracks, bridge No. 266-11, aluminum tablet stamped	733.477
Rising, 75 feet west of station; 15 feet north of center of track, iron post stamped	734.039
Rising, in front of station; top of rail	735.6
Champaign, 2 miles west of; in south side of west abutment of a small I beam bridge on Big Four Railway, 15 feet south of center of track, aluminum tablet stamped	748.273

URBANA QUADRANGLE.

Champaign, 53 feet southeast of southeast corner of Engineering building at University of Illinois, iron post stamped "Prim. Trav. Sta. No. 1	721.050
Champaign, on south side of east entrance to Engineering building, University of Illinois, aluminum tablet stamped	722.721

CHAMPAIGN VIA WABASH RAILROAD SOUTHEAST TO SIDNEY, THENCE EAST TO CATLIN.

Champaign, southwest corner of University and Goodwin Sts., top of sewer trap	731.94
Urbana station, in front of, top of rail	713.9
Urbana, 1059 feet east of station, 220 feet north of Wabash tracks, 45 feet south of Big Four tracks, in southwest corner of stone culvert under Big Four railroad, aluminum tablet stamped	704.688
Urbana, 789 feet east of station; 45 feet east of mile-post Cha. 2, Tol 285, at lock to switch south of tracks, top of spike	711.20
Mira, 2.08 miles northwest of; spike in east side of mile-post at Cha. 3, Tol. 284	745.97
Mira, 1.03 miles northwest of; spike in east side of mile-post Cha. 4, Tol. 283	719.16
Mira, at road crossing, top of rail, old elevation	695.8
Mira, 30 feet west of track, 30 feet south of road, 3 feet west of fence corner, iron post stamped "695, 1906"	696.033

Feet.

Deers, 1.99 miles northwest of; spike in west side of mile-post Cha. 6, Tol. 281 ..... 686.61
Deers, 0.99 miles northwest of; spike in west side of mile-post Cha. 7, Tol. 280 ..... 690.61
Deers, 65 feet west of track, 25 feet south of road, 70 feet north of store and P. O., of F. C. Edwards, at northeast corner of barn, iron post stamped "691, 1906" 691.902
Sidney, 2.57 miles northwest of; spike in west side of telegraph pole. 671.13
Sidney, 1.73 miles northwest of; spike in west side of telegraph pole. 664.32
Sidney, 0.75 mile northwest of; in west side of whistle post, top of spike 662.73
Sidney, in front of station; top of rail (old elev. marked 669)..... 665.8
Sidney, high school, in southwest corner of, aluminum tablet stamped "673, 1906" 672.523
Sidney, high school, cross mark on southwest corner of stone step, at front entrance, is level with brick pavement..... 670.68
Homer, 5.29 miles west of; north side of abutment of Wabash bridge over C. & E. I. R. R., center of chisled square on second tier of concrete 682.12
Homer, 4.38 miles west of; spike in south side of telegraph pole..... 677.99
Homer, 3.56 miles west of; 45 feet north of milepost St. L. 163, T. 273, 35 feet north of track, 5 feet north of telegraph pole, iron post not stamped 667.976

FITHIAN QUADRANGLE.

Homer, 2.38 miles west of; spike in north side of telegraph pole..... 667.92
Homer, 1.26 miles west of; 90 feet northwest of, whistlepost, R. R. spike in north side of telegraph pole..... 669.72
Homer, 6.05 feet west of station; 30 feet north of track, 25 feet west of road, at east side of asphalt pavement, aluminum tablet stamped "674, 1906" 674.433
Homer, in front of station; top of rail..... 676.4
Fairmount, 7.59 miles west of; 105 feet northwest of whistlepost, top of spike in north side of telegraph pole 668.20
Fairmount, 6.64 miles west of; 275 feet northeast of milepost St. L. 168, T. 268, railroad spike in north side of telegraph pole..... 670.65
Fairmount, 5.59 miles west of; 35 feet north of track, 25 feet east of road, near fence corner, iron post stamped "664, 1906"..... 664.341
Fairmount, 4.59 miles west of; in east end of board at road crossing, top of spike 673.09
Fairmount, 3.69 miles west of; spike in north side of milepost St. L. 171, Tol. 265 ..... 675.86
Fairmount, 2.69 miles west of; 40 feet north of track, 50 feet north of milepost St. Louis 172, Tol. 264, iron post stamped "655, 1906"... 655.806
Fairmount, in front of station; top of rail..... 661.5
Fairmount, 1.71 miles west of; 240 feet northwest of milepost St. L. 178, T. 263, top of spike on north side of lock..... 656.789
Fairmount Junction, 0.77 mile west of; 250 feet west of old coal mine, top of spike north side of lock to switch 655.09
Fairmount Junction, 56 feet northwest of; 50 feet west of C. & E. I. R. R. tracks, 60 feet west of signal station; 35 feet north of Wabash tracks, in fence corner, iron post stamped "654, 1906"..... 654.471
Fairmount Junction, C. & E. I. R. R. and Wabash railroad, top of rail 656.13
Fairmount Junction, 1.01 miles east of; top of second bolt from west end on south side of bridge, 120 feet west of road crossing..... 656.35
Fairmount Junction, 2.32 miles east of; R. R. spike in north side of milepost St. L. 177, Tol. 259..... 667.172
Fairmount Junction, 3.32 miles east of; 40 feet directly north of milepost St. L. 178, Tol. 258, 30 feet north of track, iron post stamped "672, 1906" 672.328

	Feet.
Fairmount Junction, 4.32 miles east of; spike in west side of mile-post St. L. 179, Tol. 257	673.96
Middle of bridge No. 7, over stream and wagon road, top of rail	664.84
Surface of water at above, October 29, 1906	648.

DANVILLE QUADRANGLE.

Fairmount Junction, 5.09 miles east of; top of 5th bolt from west end on south side, of bridge No. 6	665.64
Catlin, in front of station; top of rail	663.8
Catlin station, T. 19 N., R. 12 W., sec. 34, 195 feet north of track, 30 feet west of road, at "Champion's Corner," iron post stamped "658, 1906"	657.345
Old elevation	658.423
New elevation	657.345
Difference	1.078

Precise Leveling.

OLNEY, NEWTON, GREENUP, BRADBURY, MATTOON, OAKLAND, KANSAS, SIDELL AND FITHIAN QUADRANGLES—COLES, CUMBERLAND, DOUGLAS, JASPER AND RICHLAND COUNTIES.

The following is a list of unadjusted values derived from a precise level line run from a bench mark of the U. S. C. & G. Survey's line of transcontinental levels at Olney, described as follows: "Square cut in one of the columns at north face of court house at Olney marked

B_3
U. S. C. & G. S.
B[]M
1881

its elevation is accepted as 485.332. This line was run north over the several railroads noted and connects at Fairmount Junction with precise levels of 1906 run from Champaign to Catlin, an extension of the precise levels of 1905 from Pekin.

This connection makes the elevation of the bench mark at Fairmount Junction as derived from Olney 0.740 foot lower than that derived from Pekin.

The leveling was done by Mr. T. A. Green, levelman, under the direction of Mr. S. S. Gannett, geographer.

OLNEY NORTH TO FAIRMOUNT JUNCTION—NORTH BY ILLINOIS CENTRAL RAILROAD TO LERNA.

OLNEY QUADRANGLE.

	Feet.
Olney, Richland county, cut at the base of one of the columns at the north face of the court house, marked B_3 USC & GS B[]M 1881	485.332

Feet.

Olney, Richland county court house, in top of west stone balustrade of steps at south entrance, aluminum tablet stamped "483, 1906".. 482.860
Olney, in front of station; top of rail..... 471.9
Olney, 0.86 mile north of; 30 feet west of track, 90 feet south of lock to switch at C. H. & D. junction, top of rail driven in ground..... 460.876
Olney, 1.85 miles north of; top of south end of terra cotta drain pipe under road, 10 feet west of center of track..... 465.311

NEWTON QUADRANGLE.

Olney, 2.87 miles north of; north of road crossing, on east side of cattle guard, top of second spike from north end 466.08
Olney, 2.87 miles north of; 45 feet west of road crossing, 40 feet north of road, in southeast corner of lot owned by J. M. Fleming, iron post stamped "465, 1906" 464.744
Olney, 3.67 miles north of; second bolt from north end, east side of bridge B. 175-41 ..... 464.31
Olney, 4.38 miles north of, north end of drain pipe west of track, 15 feet south of whistle post 472.37
Olney, 5.36 miles north of; north end of drain pipe east side of track, 27 feet southeast of whistle post..... 473.48
Olney, 5.36 miles north of; 30 feet east of tracks, 40 feet southeast of private road crossing, 50 feet southeast of whistle post, 10 feet south of gate to house, iron post stamped "475, 1906"..... 474.523
Olney, 6.18 miles north of; top of third bolt from south end, west side of bridge B 172-89 ..... 460.59
Dundas, in front of station; top of rail..... 477.6
Dundas, 439 feet north of station; 50 feet northeast of road crossing, 30 feet east of track, in southwest corner of Dundas Rolling Mill, aluminum tablet stamped "480, 1906" 480.507
Dundas, 0.88 mile north of; top of rail at north end of emergency rail rack at milepost 171-76 ..... 481.49
West Liberty, in front of station; top of west rail..... 483.2
West Liberty, 0.53 mile north of; nail in top of center of emergency rail rack at milepost 170-77 ..... 485.9
West Liberty 1.59 mile north of; 160 feet north of milepost, 169-78 70 feet south of bridge B 168-93, 590 feet south of road crossing, 30 feet east of tracks, east of right of way line, iron post stamped "480, 1906" 480.468
West Liberty, 2.52 miles north of; nail in top of south post, emergency rail rack at milepost 168-79 ..... 488.60
West Liberty, 3.52 miles north of; nail in top of north post of emergency rail rack at milepost 167-80 ..... 498.76
West Liberty, 4.52 miles north of; 8 feet west of milepost 166-81, iron post stamped "506, 1906" 506.343
West Liberty, 5.52 miles north of; nail in top of north post emergency rail rack at milepost 165.82 ..... 509.19
Boos, in front of station; top of rail..... 516.6
Boos, 0.85 mile north of; nail in top of north post emergency rail rack at milepost 164-83 ..... 513.99
Boos, 1.84 miles north of; 40 feet northeast of milepost 163-84, in fence corner, 25 feet east of track, 15 feet east of warning post, 50 feet southeast of road crossing, iron post stamped "524, 1906"..... 524.431
Boos, 2.84 miles north of; spike in south post emergency rail rack, at milepost 162-85 ..... 523.68
Boos, 3.84 miles north of; nail in top of north post emergency rail rack, at milepost 161-86 ..... 528.81
Newton, in front of junction just south of station; top of rail..... 506.6
Newton, 180 feet northwest of station; 70 feet west of railroad crossing, 20 feet west of water plug on south side of road, iron post stamped "512, 1906" 512.203

GREENUP QUADRANGLE.

Center of iron railroad bridge over Embarrass River..... 496.52
Center of bridge over large pond..... 490.56

	Feet.
Newton, 1.06 miles north of; nail in top of north post emergency rail rack at mile post 159-88	487.18
Center of bridge B 158-73	490.69
Newton, 2.06 miles north of; spike in north post emergency rail rack at mile post 158-89	510.26
Newton, 3.03 miles north of; 165 feet south of milepost 157-90, in fence corner, 30 feet east of track, 10 feet north of private road crossing, iron post stamped "538, 1906"	538.020
Newton, 3.65 miles north of; at signpost "Falmouth 1 mile" warning post marked "U. S. 544," top of rail at road crossing	544.1
Newton, 4.06 miles north of, nail in top of north post emergency rail rack at mile post 156-91 section post B 26-B-25	546.32
Falmouth, 60 feet south of station; at road crossing, top of rail	548.86
Falmouth, 0.47 mile north of; 346 feet north of mile post 155-92, at lock to switch, top of spike east side of lock	551.92
Falmouth, 1.4 miles north of; 40 feet east of track, at edge of fence 50 feet east of mile post 154-93, 175 feet west of oil derrick, iron pipe stamped "564, 1906"	564.094
Falmouth, 2.4 miles north of; nail in top of middle post emergency rail rack, at mile post 153-94	561.68
Middle of bridge B 152-56, top of rail	568.5
Middle of bridge 152-27, top of rail	563.6
Rose Hill, nail in top of middle post emergency rail rack at mile post 152-95	566.82
Rose Hill, in front of station, top of rail	566.5
Middle of bridge B-159-08, top of rail	564.9
Rose Hill, 1.05 miles north of; 553 feet north of mile post 151-96, in fence corner, 35 feet southeast of road crossing, iron post stamped "566, 1906"	565.848
Rose Hill, 1.94 miles north of; nail in top of south post emergency rail rack at mile post 150-97	571.50
Rose Hill, 2.98 miles north of; nail in top of middle post rack emergency rail at mile post 149-98	580.26
Hidalgo, 120 feet south of station, at road crossing; top of rail	582.3
Hidalgo, in front of station, top of rail	582.3
Hidalgo, 0.31 mile north of; 30 feet west of track, 8 feet west of mile post 148-99, iron post stamped "581, 1906"	581.490
Middle of bridge B 147-46, top of rail	566.4
Hidalgo, 1.28 miles north of; nail in top of south post for emergency rail rack, 150 north of sign "Hidalgo 1 mile"	543.97
Bridge B 146-84, top of rail	533.6
Middle of bridge B 146-39, top of bolt	529.56
Hidalgo, 2.27 miles north of; nail in top of south post emergency rail rack 240 feet south of mile post 146--101, on east side of track, in cut	536.83
Middle of bridge B 145-72, over road, top of bolt	552.91
Center of bridge B 145-51, over road, top of rail	563.8
Road crossing west of school house, top of rail	583.2
Hidalgo, 3.37 miles north of; 245 feet north of mile post 145-102, 30 feet east of tracks, 9 feet north of center of road through field, at edge of right of way, iron post stamped "593, 1906"	592.854
Hidalgo, 4.31 miles north of; nail in top of south post emergency rail rack at mile post 144-103	598.52
Hull siding, in front of signpost, top of rail	593.7
Hidalgo, 5.31 miles north of; nail in top middle post emergency rail rack at mile post 143-104	582.41
Bridge B-142-86, top of bolt	576.80
Bridge B-142-74, top of bolt	570.05
Bridge B-142-51, over county road, top of rail	557.4
Greenup, junction Illinois Central and Vandalia line, top of rail	553.1
Greenup, in front of I. C. R. R. station, top of rail	553.1
Greenup, 700 feet northwest of station, 40 feet north of track, 570 feet southeast of mile post 142-105, iron post stamped "543, 1906"	542.903

	Feet.
Middle of bridge B 142-76, top of rail	531.7
North end of railroad bridge over Embarrass river, top of rail	535.7
Surface of water at above, Sept. 15, 1906	513
Greenup, 1.23 miles northwest of; nail in top of east post emergency rail rack, 250 feet west of road crossing	542.20
Greenup, 2.23 miles northwest of; at Norveil siding, nail in east post emergency rail rack, at mile post 140-107	587.91

BRADBURY QUADRANGLE.

Greenup, 3.18 miles northwest of; 45 feet northwest of road crossing, 25 feet north of warning post, 15 feet west of wagon road, iron post stamped "553, 1906"	552.600
Middle of bridge B 138-08, top of rail	553
Greenup, 4.24 miles northwest of; nail in top of west post emergency rail rack, mile post 138-109	550.255
Middle of bridge B 137-80, top of rail	558.7
Bridge just south of road crossing, top of bolt	584.85
Greenup, 5.24 miles northwest of; 0.3 mile south of Toledo, nail in top of north emergency rail rack at mile post 137-110	592.96
Toledo, in front of station; top of rail	600.3
Toledo, 0.75 mile north of, 210 feet north of mile post 136-111, in fence corner, 35 feet west of track, 10 feet north of private road to Glenn Mowell house, iron post stamped "602, 1906"	602.077
Toledo, 1.71 miles north of; nail in top of north post emergency rail rack, at mile post 135-112	602.09
Toledo, 2.71 miles north of; nail in tie at mile post 134-113	601.9
Bradbury, top of rail at road crossing south of station	608.2
Bradbury, in front of station, top of rail	608.3
Bradbury, 630 feet north of station, 25 feet west of track, 3 feet west of mile post 133-114, iron post stamped "607, 1906"	607.344
Bradbury, 1.20 miles north of; 390 feet north of mile post 132-115, spike in west side of whistle post	630.25
Bradbury, 2.12 miles north of; nail in top of north post emergency rail rack at mile post 131-116	661.40
Sign post "Janesville 1 mile," road crossing, top of rail	668.5
Bradbury, 2.94 miles north of, 0.53 miles south of Janesville, 30 feet west of track, in fence corner, 20 feet south of road, iron post stamped "676, 1906"	675.795
Janesville, in front of station; top of rail	694.1
Janesville, 0.65 mile north of; nail in middle post emergency rail rack at mile post 129-118	704.24
Janesville, 1.65 miles northwest of; railroad spike in top of west post emergency rail rack, at mile post 128-119	721.60
Janesville, 2.64 miles northwest of; nail in top of east post emergency rail rack at mile post 127-129	737.61
Janesville, 2.60 miles northwest of, 235 feet south of mile post 127-120, in fence corner, 35 feet east of track, iron post stamped "735, 1906"	735.150
Sign post "Lerna 1 mile," top of rail at road crossing	744.8

MATTOON QUADRANGLE.

Janesville, 3.31 miles northwest of, in top of south end of iron drain pipe, 3 feet north of waterway B 126-33	741.14
Lerna Junction, Illinois Central and Toledo, St. Louis and Western R. R., top of rail	753.5
Lerna, southeast corner of station, on east side, corner of platform, 113 feet northwest of junction, iron post stamped "754, 1906"	753.528

NORTHEAST BY TOLEDO, ST. LOUIS AND WESTERN RAILROAD TO BROCTON.

Lerna, 1.06 miles northeast of, at road crossing, cross mark in west end of terra cotta drain pipe, 10 feet north of track	740.13

	Feet.
Lerna, 2 miles northeast of, 60 feet east of mile post "St. Louis 125-T 326," 10 feet south of rail rack, in south end of terra cotta drain pipe, chiseled hole	720.605
Lerna, 3.01 miles northeast of, 40 feet north of track, 20 feet east of road, iron post stamped "708, 1906"	707.801
Lerna, 3.99 miles northeast of, 250 feet northeast of mile post "St. L. 127-T. 324," 20 feet north of whistle post, chiseled hole in top of rock	677.10
Middle of bridge 324, top of rail	673.9
Surface of water at above, Sept. 22-24, 1906	641
Lerna, 5 miles northeast of, 440 feet southwest of road crossing, top of 13th bolt from east end, south side of bridge	639.20
Surface of water, Sept. 22-24, 1906	614
Middle of bridge 323 A, top of rail	613.34
Lerna, 5.74 miles northeast of, 50 feet north of track, 25 feet east of road, 20 feet west of silver poplar tree, iron post stamped "615, 1906"	614.760
Middle of bridge 322, top of rail	621.6
Surface of water, Sept. 25, 1906	595
Lerna, 6.87 miles northeast of, 200 feet northeast of overhead bridge, railroad spike in west end of north support of span for warning of approach to overhead bridge	635.40
Middle of bridge over steam and electric car line, top of rail	641.8
Surface of water at above, Sept. 25, 1906	613
Lerna, 7.85 miles northeast of; nail in top of west end of wooden culvert over drain east side of track	650.77
Charleston, in southwest corner of Clover Leaf station, 5 feet east of entrance to baggage room,in stone coping, aluminum tablet stamped "672, 1906"	672.016
Charleston, Coles county court house, 15 feet west of north entrance, in section of building occupied by U. S. P. O., in west end of top step, aluminum table stamped "686, 1906"	685.748
Charleston, in front of station (Clover Leaf R. R.), top of rail	677.7

OAKLAND QUADRANGLE.

Charleston, 1.01 mile north of R. R., spike in west side of telegraph pole	669.41
Charleston, 2.06 miles north of; spike in west side of telegraph pole	675.04
Charleston, 2.43 miles north of, 10 rails north of road crossing, top of rail	688.2
Charleston, 3.68 miles north of, 35 feet east of track, 25 feet north of county road, in southwest corner of G. W. Wasson lot, iron post stamped "686, 1906"	686.078
Charleston, 4.39 miles north of, at mile post "St. L. 136-Toledo 315," top of bolt in board at private road crossing	684.54
Charleston, 5.40 miles north of; spike in east side of mile post "St. L. 137-T. 314"	678.76
Fairgrange station, in front of station, top of rail	682.3
Fairgrange, 0.95 mile northeast of, 45 feet south of track, 25 feet south of warning post, 25 feet east of county road, 2 feet west of fence corner, iron post stamped "686, 1906"	686.294
Fairgrange, 1.72 miles northeast of, 165 feet northeast of mile post "St. L. 138-T. 312," top of third bolt from south end of east side of bridge No. 312	670.10
Bushton, in front of station, top of rail	671.8
Bushton, 0.85 mile northeast of, at road crossing, spike in west side of warning post	668.02
Bushton, 0.85 mile northeast of, 50 feet northeast of road crossing, 30 feet north of county road, near fence corner, iron post stamped "666, 1906"	665.797
Bushton, 1.68 miles northeast of; nail in board on east side of private road crossing, 333 feet northeast of mile post "St. L. 141-T. 319"	664.52

	Feet.
Rardin, in front of station, top of rail	664.1
Rardin, 0.45 mile northeast of station, top of second bolt from south end east side of bridge No. 309 B, 75 feet northeast of mile post "St. L. 142-T. 309"	659.64
Rardin, 1.58 miles northeast of, 58 feet south of private road crossing 10 feet south of angle in road, iron post stamped "658, 1906"	657.559
Bridge No. 308 over Embarrass river	638.89
Surface of water at above, Sept. 8, 1906	589
Rardin, 2.49 miles northeast of, 150 feet south of road crossing, top of spike in west side of bridge No. 307	650.55
Rardin, 3.47 miles northeast of; spike in east side of mile post "St. L. 145-T. 306"	658.82
Rardin, 4.42 miles northeast of, R. R. spike in east side of mile post "St. L. 145-T. 305"	660.23
Oakland, 839 feet south of junction, top of spike in east side of road crossing, 130 feet northeast of mile post "St. L. 147-T. 304"	653.65
Oakland, 820 feet south of junction, 60 feet west of track, 140 feet northwest of mile post "St. L. 147-T. 304, 25 feet south of wagon road, iron post stamped "652, 1906"	652.233
Oakland, at Clover Leaf junction with Vandalia Railroad, top of rail	655.8
Oakland, 0.95 miles northeast of, top of spike in board on west side of road crossing, 145 feet south of mile post "St. L. 148-T. 308"	656.56

KANSAS QUADRANGLE.

Oakland, 1.97 miles north of; spike in west side of first telegraph pole south of mile post "St. L. 149-T. 302"	658.81
Oakland, 2.98 miles north of; R. R. spike in top of post at mile post "St. L. 150-T. 301"	659.18
Oakland, 2.98 miles north of, 50 feet east of track, 30 feet east of mile post "St. L. 150-T. 301," 465 feet north of small bridge No. 302, in edge of field, iron post stamped "661, 1906"	660.804
Coles-Douglas county line post, 30 feet north of, top of rail	660.7
Douglas-Edgar county line post, top of rail	655.60
Oakland, 4.08 miles north of, 560 feet north of mile post "St. L. 151-T. 300, top of spike in board on east side of road crossing	655.13
Oakland, 4.89 miles north of, 411 feet southwest of mile post "St. L. 152-T. 299, top of spike in east side of bridge No. 300 B, 30 feet south of road crossing	660.52
Oakland, 5.89 miles northeast of, west side of road crossing, top of spike	664.25
Oakland, 5.89 miles northeast of, 0.47 miles southwest of Brocton, 65 feet north of road crossing, 35 feet west of track, in fence corner, iron post stamped "661, 1906"	661.393
Brocton, junction Clover Leaf and C. H. & D. R. R., top of rail	661.9

NORTH VIA C. H. & D. R. R. TO SIDELL.

Brocton, 0.44 mile northeast of, top of spike in board on west side of road crossing	663.00
Brocton, 1.18 miles north of; nail in top of fence, adjoining cattle guard, on east side	668.06

SIDELL QUADRANGLE.

Brocton, 2.28 miles north of; R. R. spike in east side of telegraph pole (third pole south of road crossing)	677.2
Brocton, 2.36 miles northeast of, at Payne's siding, 25 feet east of tracks, 50 feet southeast of switch, 6 feet east of telephone pole, and 15 feet north of county road, iron post stamped "678, 1906"	677.872
Brocton, 3.20 miles northeast of, on west side of private road crossing, top of spike in board	663.91

	Feet.
Brocton, 4.20 miles northeast of, 18 feet south of telegraph pole, top of spike	655.242
Hughes Siding, 30 feet south of road crossing, top of rail	657.6
Brocton, 5.16 miles northeast of; R. R. spike in west side of telegraph pole	654.93
Brocton, 5.16 miles northeast of, 0.48 mile northeast of Hughes, 40 feet east side of track, 12 feet east of telegraph pole, iron post stamped "655, 1906"	655.475
Brocton, 6.17 miles northeast of, top of third bolt from south end of and east side of bridge No. 86	650.86
Hume, junction C. H. & D. R. R. and I. D. & W. R., top of rail	651.1
Hume, 0.67 mile northeast of; spike in east side of sixth telegraph pole south of water tank	651.96
Middle of bridge No. 90, top of rail	650.4
Surface of water at above, Sept. 17, 1906	640
Hume, 1.47 miles north of, 1,000 feet north of mile post, Olney 78, Sidell 7, 40 feet east of track, 90 feet northeast of whistle post, iron post stamped "645, 1906"	645.509
Hume, 2.28 miles north of, spike in west side of telegraph pole, 30 feet north of mile post, Olney 79, Sidell 6	652.85
Hume, 3.3 miles north of, top of second bolt from north end on east side of bridge No. 94, 60 feet north of mile post, Olney 80-Sidell 5	664.66
Surface of water at above, October 17, 1906	660
Hume, 4.3 miles north of, 120 feet north of mile post, Olney 81-Sidell 4, nail in top of grade stake No. 21	691.33
Hume, 4.34 miles north of, 330 feet north of mile post, Olney 81-Sidell 4, 25 feet west of track and 5 feet north of private road, iron post stamped "693, 1906"	692.78
Hildreth, in front of station, top of rail	713.5
Hildreth, 64 feet north of station, R. R. spike in west side of telegraph pole, 30 feet east of mile post, Olney 82-Sidell 3	716.75
Hildreth, 1.15 miles north of, top of first bolt from south end west side of bridge No. 99	695.53
Hildreth, 1.99 miles north of, at road crossing, 150 feet north of Archie Siding, 30 feet west of track and 10 feet south of road, iron post stamped "691, 1906"	691.194
Sidell, 277 feet south of station; top of spike in west side of board walk crossing track	681.04
Sidell, high school, in west side of; northwest corner of, in stone water shed, 2 feet south of corner of building, aluminum tablet stamped "684 1906"	684.394
Sidell station, in front of station; top of rail	681.1
Sidell, 0.91 mile east of; junction main line, top of rail	675.1

NORTH BY ROSSVILLE BRANCH C. & E. I. R. R. TO FAIRMOUNT JUNCTION.

Sidell, 0.93 mile east of; R. R. spike in north side of telegraph pole 10 feet east of section post No. 59, 40 feet north of tracks	675.04
Sidell, 2.05 miles north of; R. R. spike driven in west side of telegraph pole, 255 feet south of yard limit sign	668.04
Sidell, 3.13 miles north of; top of spike in north end of board on east side of private road crossing	682.32
Sidell, 3.13 miles northeast of; 50 feet east of track, 10 feet north of private road, iron post stamped "679 1906"	679.069
Maizeton, road on crossing south of siding, top of rail	682.2
Sidell, 4.27 miles north of; west end of iron drain pipe, under railroad, top of	677.07
Sidell, 5.34 miles north of; nail in top of north post emergency rail rack at mile post C 137-T-257	681.44
Jamaica, in front of station; top of rail	682.5
Jamaica, 145 feet northeast of station; 100 feet west of track, 30 feet north of road, at southeast corner of Joe Collin's store (owned by Wm. Gohain), iron post stamped "677 1906"	677.122

FITHIAN QUADRANGLE.

	Feet.
Jamaica, 1.07 miles north of; R. R. spike driven in west side of second telegraph pole north of telegraph pole 135-5	673.59
Jamaica, 2.22 miles north of; 60 feet west of track, 70 feet northwest of milepost C 134-T 260, 195 feet northwest of switch, iron post stamped "668 1906"	667.560
Jamaica, 3.19 miles north of; R. R. spike driven in west side of telegraph pole, 90 feet southwest of milepost C 133-T 261	662.24
Fairmount Junction, junction of C. & E. I. and Wabash R. R., top of rail	655.4
Fairmount Junction, 56 feet northwest of; 50 feet yest of C. & E. I. tracks, 60 feet west of signal tower, 35 feet north of Wabash tracks, in fence corner, iron post stamped "654 1906"	654.471

(Elevation of above bench mark by precise leveling from Pekin, as given in other list.)

Precise Leveling.

DUQUOIN, ELDORADO, GALLATIA, MULKEYTOWN, SHAWNEETOWN AND THOMPSONVILLE QUADRANGLE—FRANKLIN, GALLATIN, PERRY AND SALINE COUNTIES.

The following are the unadjusted results of a line of precise levels run from Duquoin southeastward along the Illinois Central Railroad to Shawneetown. The elevations are based upon the bench mark "R_3" on the U. S. Coast and Geodetic Survey precise level line Cairo to Odin, Ill. It is the bottom of a square cut in corner of stone sill at main door opposite Illinois Central Railroad station and its accepted elevation is 462.141 as obtained by the adjustment of 1903 made by the Coast and Geodetic Survey.

The method, type of instrument, and limit of error are the same as those now used by the U. S. Coast and Geodetic Suvery. The self reading rods used were 3.5 yards in length graduated to yards and hundredths and reading by estimation to thousandths, which enables computation to be made directly in feet instead of meters as is done by the Coast Survey. On all sections upon which the forward and backward measures in feet differed more than $0.017\sqrt{D}$ (in which D is the distance between bench marks in miles) both forward and backward measures were repeated until a pair run in opposite directions came within limits, and all other requirements necessary to obtain accurate results were closely adhered to.

The leveling was done in 1906 by Mr. T. A. Green, levelman, under the direction of Mr. S. S. Gannett, geographer.

The standard bench marks are stamped with figures of elevation and year. Many are stamped with a value one foot too small but will probably be restamped when further work is done in the locality.

DUQUOIN SOUTHEASTERLY ALONG ILLINOIS CENTRAL RAILROAD TO SHAWNEETOWN.

	Feet.
Duquoin, U. S. Coast and Geodetic Survey, B. M. R., the bottom of a square cut in corner of stone sill at main door opposite Illinois Central railroad station, the cavity is marked thus: (———)	462.141

	Feet.
Duquoin, 600 feet east of station; in east brick wall of Exchange Bank, aluminum tablet stamped "468 1906"	468.091
Duquoin, in front of station; top of rail	463.4
Duquoin, 1.1 miles southeast of; railroad spike in side of M.P. "E. St. L. 72"	459.31
Duquoin, 2.2 miles southeast of; at M.P. 73, nail in top of south rack for emergency rail	418.80
Duquoin, 3.2 miles east of; 60 feet west of creek, 40 feet north of railroad just south of fence corner, iron post stamped "396 1906"	396.071
Duquoin, 4.2 miles east of; at milepost 75, nail in top of east rack for emergency rail	392.24
McDonald, 0.4 mile west of; 200 feet west of brick yard, at old switch and private road crossing, top of rail	399.7
McDonald, in front of station; top of north rail	395.6
McDonald, 265 feet east of station, at M.P. 76, nail in top of east rack for emergency rail	395.52
McDonald, 1 mile southeast of; 60 feet directly north of milepost "East St. Louis 77 mi.," "Eldorado 44 mi.," iron post stamped "402 1906"	401.562
McDonald, 1.5 miles southeast of; in board walk at private road crossing, top of bolt	425.24
McDonald, 2 miles southeast of; 360 feet southeast of M.P. 78, in south side of railroad bridge over small stream, east end, top of bolt	437.95
Mulkeytown, in front of station; top of rail	424.1
Mulkeytown, 324 feet south of station; in east side of corner stone at hall of "Modern Woodmen of America," aluminum tablet stamped "449 1906"	448.689
Mulkeytown, 1 mile east of; at M.P. 89, nail in top of east rack for emergency rail	461.39
Mulkeytown, 1.8 miles east of; center of track, in board walk at private road crossing, top of bolt	449.66
Christopher, 0.1 mile west of; at lock and switch, top of railroad spike	442.15
Christopher, in front of station; top of rail	438.6
Christopher, in southwest corner of Christopher National Bank, aluminum tablet stamped "443 1906"	443.530
Christopher, 0.8 mile east of; at M.P. 83, nail in top of west rack for emergency rail	417.22
Christopher, 1.7 miles east of; at M.P. 84, nail in top of east rack for emergency rail	411.56
Buckner, in front of station; top of rail	408.2
Christopher, 3.0 miles east of; south side of small railroad bridge over stream	391.72
Christopher, 2.8 miles east of; 348 feet west of small railroad bridge over stream, 150 feet southeast of house occupied by Isaac Denton, iron post stamped "392 1906"	392.632
Christopher, 3.4 miles east of; in tie lying 30 feet south of track, spike	392.69
Christopher, 3.8 miles east of; just east of M.P. 86, south side of small railroad bridge over road, top of bolt	385.15
Christopher, 4.8 miles east of; at milepost 87, nail in top of post	405.04
Christopher, 5.7 miles east of; 150 feet southeast of; road crossing, at northeast corner of house occupied by W. M. Wolf, iron post stamped "438 1906"	438.825
Christopher, 6.7 miles east of; 50 feet east of water tank north of track, south side coal bin, nail in top	449.80
Benton (Franklin county) court house, 1,507 feet north of station; in stone step just south of west entrance, aluminum tablet stamped "473 1906"	475.496
Benton, in front of station; top of rail	470.4
Benton, 0.3 mile east of; C. & E. I. junction with I. C. R. R., top of rail	470.79
Benton, 0.9 mile east of; north end of iron drain pipe	433.30

Feet.

Benton, 1.9 miles east of; railroad spike in north side of post..... 426.34
Benton, 2.3 miles southeast of; 90 feet directly north of M.P. "E. St. Louis 92, Eldorado 29," iron post stamped "405 1906"..... 406.269
Benton, 3.3 miles southeast of; at mile post 93, nail in west rack for emergency rail..... 392.17
Benton, 4.3 miles southeast of; at M.P. 94, nail in west rack for emergency rail..... 445.71
Benton, 5.1 miles southeast of; 0.3 mile west of Smothers, at road crossing, railroad spike in board walk..... 464.86
Smothers, in front of station; top of rail..... 481.2
Smothersville P. O., 260 feet southeast of road crossing, at northwest corner of store, kept by M. M. Moore, iron post stamped "479 1906". 479.558
Smothersville, 1.0 mile southeast of; at M.P. 96, nail in top of east rack of emergency rail..... 473.28
Parrish, 200 feet northeast of road crossing, at southwest corner of store kept by Brown & Moore, iron post stamped "438 1906"..... 439.164
Parrish, in front of station; top of rail..... 437.8
Parrish, 1.1 miles southeast of; at M.P. 98, nail in west rack for emergency rail..... 428.10
Parrish, 2.1 miles southeast of; M.P. 99, nail in west rack for emergency rail..... 443.60
Thompsonville, 50 feet north of track, at crossing, in right of way post 502.08
Thompsonville, 600 feet south of road crossing, 100 feet east of brick school house, iron post stamped "494 1906" Prim. Trav. Sta. No. 4" 495.065
Thompsonville, in front of station; top of rail..... 499.6
Thompsonville, 0.7 mile southeast of; at M.P. 101, top of east rack of emergency rail..... 480 56
Thompsonville, 1.7 miles southeast of; at M.P. 102, top of west rack for emergency rail 494.93
Thompsonville, 2.7 miles southeast of; at M.P. 103, top of east rack for emergency rail..... 451.79
Westend, 75 feet north of station; in south wall of "Westend Rolling Mill," aluminum tablet stamped "429 1906"..... 430.171
Westend, 60 feet east of station; top of rail..... 425.6
Westend, 1.1 miles southeast of; at M.P. 105, nail in top of west rack for emergency rail..... 408.88
Westend, 2.1 miles southeast of; at milepost 106, nail in top of west rack for emergency rail..... 402.90
Westend, 3.1 miles southeast of; M.P. 107, nail in top of west rack for emergency rail..... 398.85
Rileyville, in front of station; top of rail..... 398.6
Rileyville, 0.71 mile southeast of; 20 feet northwest of cattle guard, in corner of fence at point where county road jogs north from railroad, iron post stamped "392 1906"..... 392.886
Rileyville, 1.9 miles southeast of; at M.P. 109, nail in top of west rack for emergency rail..... 411.87
Rileyville, 2.9 miles southeast of; at M.P. 110, nail in top of east rack for emergency rail..... 417.99
Galatia, 0.3 mile west of station; at "Galatia Rolling Mill," in southwest foundation of old elevator, aluminum tablet stamped "397 1906" 397.850
Galatia, in front of station; top of rail..... 401.2
Galatia, 0.2 mile southeast of; at M.P. 111, nail in top of west rack for emergency rail..... 412.42
Galatia, 1.2 miles southeast of; at M.P. 112, nail in top of west rack of emergency rail..... 386.89
Galatia, 2.2. miles southeast of; 60 feet north of M.P. 113, nail in stake 414 75
Galatia, 3.18 miles southeast of; 20 feet directly south of M.P. "E. St. Louis 114, Eldorado 7," inside fence, iron post stamped..... 394.067

	Feet.
Raleigh, in front of station; top of rail	406.9
Galatia, 4.1 miles southeast of; 150 feet west of M.P. 115, north side of railroad bridge, top of bolt	406.47
Raleigh, 0.60 mile southeast of; at M.P. 116, nail in top of east rack for emergency rail	390.85
Raleigh, 1.59 miles east of; 70 feet west of mile post "E. St. L. 117 mi., Eldorado 4 m.," 62 feet south of center of tracks, iron post stamped "390 1906"	390.763
Raleigh, 2.6 miles east of; at M.P. 118, nail in top of west rack for emergency rail	403.000
Raleigh, 3.6 miles east of; at M.P. 119, nail in top of west rack for emergency rail	403.28
Raleigh, 4.6 miles east of; at M.P. 120, nail in top of east rack for emergency rail	405.70
Eldorado, 30 feet south of southwest corner of Grand Hotel, at edge of pavement, iron post stamped "388 1905"	387.568
Eldorado, Big Four and L. & N. R. R. junction; just east of station, top of rail	391.6
Eldorado, 0.5 mile southeast of; at M.P. 125, nail in top of north rack for emergency rail	386.68
Eldorado, 1.5 miles southeast of; at M.P. 126, nail in top of east rack for emergency rail	400.40
Eldorado, 2.5 miles southeast of; 40 feet north of M.P. 127, at switch, spike in tie	408.87
Grayson, 30 feet west of station; top of rail	406 8
Grayson, 0.49 mile southeast of; 40 feet north of center of track, inside wire fence, iron post stamped "1906"	392.313
Grayson, 0.9 mile southeast of; at M.P. 128, top of east rack for emergency rail	374.28
Grayson, 1.9 miles southeast of; at M.P. 129, top of east rack for emergency rail	370.83
Grayson, 3.1 miles southeast of; 40 feet northwest of road crossing, on west side of road, iron post stamped "1906"	362,708
Grayson, 4.1 miles southeast of; nail in top of log	352 62
Equality, at northwest corner of L. & N. depot, iron post stamped "1906"	361.936
Equality, in front of station; top of north rail	362.6
Equality, 1.1 miles southeast of; north of track, in cut, point on rock	362.57
Equality, 1.6 miles outheast of; at west end of railroad bridge over north fork of Salina river, top of rail	356.12
Equality, 1.7 miles southeast of; at mile post 134, nail in top of west rack for emergency rail	356.17
Equality, 2.7 miles southeast of; 100 feet southeast of E. P. Fowler's residence, 40 feet north of track in fence corner, iron post stamped "1906"	376.585
Equality, 3.7 miles southeast of; at Lawlers Switch, at M.P. 136, in top of east rack for emergency rail	370.86
Equality, 5.7 miles southeast of; 60 feet north of mile post "St. Louis 138 mi., Shawneetown 6 mi.," iron post stamped "1906"	352.806
Cypress Junction L. & N. R. A. and B. & O. R. R. crossing, top of rail	355.6
Cypress Junction, 30 feet east of station, top of rail	357.7
Cypress Junction, 0.5 mile east of; at M.P. 139, southwest corner of wagon bridge over drain, 30 feet west of track, nail	364.60
Cypress Junction, 1.5 mile east of; about 100 feet west of M.P. 140, at crossing, nail in east plank north side of track	404.20
Cypress Junction, 2.5 miles east of; 330 feet west of road crossing, 50 feet north of M.P. "St. L. 141, Shawneetown 5 mi.," iron post stamped "1906"	396.176
Cypress Junction, 3.5 miles east of; at M.P. "2 Shawneetown," nail in top of old telegraph pole cut off close to ground	376.89
Shawneetown, in front of L. & N. R. R. station, top of rail	349.9

	Feet.
Shawneetown, at southwest corner of L. & N. R. R. station; iron post stamped "1906"	349.262
Shawneetown, 100 feet east of southeast corner of Riverside Hotel, in northeast corner of concrete gun rack, aluminum tablet stamped "1906"	365.632

Primary Leveling.

Evanston, Highwood and Waukegan Quadrangles—Cook and Lake Counties.

The elevations in the following lists are based upon a Chicago city bench mark, a square cut on the corner of iron plate door step at foot of round iron pillar at northeast corner of two-story brick building at southwest corner of Lincoln and Foster avenues, the elevations of which are now accepted as 610.696 feet above mean sea level; they are also adjusted to agree with the corrected elevation of bench marks of the Chicago Sanitary District at Niles Center and Desplaines. The corrected elevations are derived by adding 579.938 feet to the elevations given upon the Chicago city datum, the reference plane of which is the level of the city directrix, the zero of lake gage and low water of 1847.

The leveling done in 1897, prior to coöperation, was under the direction of Mr. R. C. McKinney, topographer, by Mr. E. S. Smith, levelman. The standard bench marks stamped "CHGO" in addition to figures of elevation are in a few cases greatly in error.

In 1906 leveling was done by Mr. Henry Bücher, levelman, under direction of Mr. W. J. Lloyd, topographer, checking levels of 1897 on the Highwood quadrangle and extending levels through the Waukegan quadrangle. Standard bench marks being stamped "ADJ 1905" in addition to figures of elevation.

Evanston Quadrangle.

Chicago north via Evanston to Winnetka.

	Feet.
Chicago, southwest corner of Clark street and Pratt avenue, northeast corner of two story brick building, base of iron column	604.126
About T. 44 N., R. 14 E., Evanston, Evanston city hall, north side of east entrance; in face of stone work of 18 inches above sill, bronze tablet stamped "CHGO 601"	602.153
Winnetka, old town hall; 30 feet north of northeast corner of, iron post stamped "CHGO 651"	651.300

Highwood Quadrangle.

Evanston west to east edge of main township, thence north to Shermanville, thence east to Winnetka.

Niles Center, near southeast corner of St. Peters Church, projecting buttress front face of stone water table, bronze tablet stamped "CHGO 663"	623.397
T. 42 N., R. 12 E., road crossing on half section line between sections 15 and 16, 0.75 miles south of Shermanville, iron post stamped "CHGO 650"	650.920

Highwood Quadrangle.

MORTON WEST VIA. DESPLAINES TO SEC. 16 ELK GROVE TOWNSHIP, THENCE NORTH VIA ARLINGTON APTAKISIC AND HALF DAY TO SEC. 33 LIBERTY TOWNSHIP.

	Feet.
Desplaines, southwest wing of north abutment of Chicago and North Western Railway bridge over DesPlaines river, on southwest corner of lower step, chiseled cross	630.908
DesPlaines, stone foundation east side of town hall, bronze tablet stamped "CHGO 642"	642.881
T. 41 N., R. 11 E., center of sec. 24; south of road at angle, 0.5 mile east of cross roads and 130 feet east of road to house of H. Beer, 0.6 foot north of fence and 2.5 feet east of north and south line fence, iron post stamped "666 ADJ 1905"	665.617
T. 41 N., R. 11 E., sec. 16, northeast quarter of; at southeast corner of cheese factory, south face of brickwork near foundation, bronze tablet stamped "716 ADJ 1905"	715.922
T. 42 N., R. 11 E., sec. 29, Arlington Height high school building, (old), front face of stone water table, at southwest corner of front projection, bronze tablet stamped "704 ADJ 1905"	703.820
T. 42 N., R. 11 E., sec. 8, northwest corner, 0.25 mile east of; T road to south, at southwest corner of T on west side of road, 8.4 feet south of fence corner and 1 foot of fence, iron post stamped "705 ADJ 1905"	705.137
T. 43 N., A. 11 E., southeast quarter; 0.5 mile south of Aptakisic, 9 feet south of forks of road west side of road, 15 feet east of wire fence, iron post stamped "682 ADJ 1905"	681.566
Aptakisic, crossing of Wisconsin Central Railroad, top of southwest rail	685.4
T. 43 N., R. 11 E., sec. 15; Halfday school building, front face of northwest corner of foundation, bronze tablet stamped "669 CHGO"	667.628
T. 43 N., R. 11 E., sec. 15, Halfday, bridge over Indian creek, at southwest corner of; top of stone abutment, 6 feet southwest of end of iron truss, aluminum tablet stamped "654 ADJ 1905"	653.640
T. 44 N., R. 11 E., sec. 34, near southwest corner of; cross roads, 1400 feet east of, on south side of, south side of road, 9.7 feet west of southwest corner of iron truss of wagon bridge over DesPlaines river, primary traverse post No. 13, stamped "651 ADJ 1905"	650.883

HALF DAY EAST TO ROAD CROSSING, CHICAGO, MILWAUKEE AND ST. PAUL RAILROAD IN SECTION 17 WEST, DEERFIELD TOWNSHIP, THENCE NORTH AND EAST TO LAKE FOREST.

T. 43 N., R. 12 E., sec. 17, southwest quarter of; water subway under Chicago, Milwaukee and St. Paul Railroad, at road crossing, east face, at northeast corner of stone work, bronze tablet stamped "667 ADJ 1905"	667.017
T. 43 N., R. 12 E., sec. 7, Everett station; in front of; top of rail	680.7
T. 44 N., R. 12 E., sec. 31, southeast corner, 0.2 mile west of; and road to east, at southeast corner and on south side of road, 50 feet east of fence corner, 1 foot north of fence, iron post stamped "675 ADJ 1905"	675.139
Durpath, T. 44 N., R. 12 E., sec. 32, at crossing of Chicago and North Western Railroad, top of rail	674.1

Waukegan Quadrangle.

SECTION 33 LIBERTY TOWNSHIP NORTH, VIA LIBERTYVILLE TO ROSECRANS, THENCE EAST AND SOUTH TO ZION CITY AND SOUTH TO LAKE FOREST.

T. 44 N., R. 11 E., sec. 33, in northeast quarter of; top of rail at crossing of Elgin, Joliet and Eastern R. R.	673.5
T. 44 N., R. 11 E., sec. 21, crossing of Chicago and Milwaukee Electric railroad at Libertyville station. top of rail	699.0

	Feet.
T. 44 N., R. 11 E., sec. 16, Libertyville, in town hall, east front at southeast corner of building, in stone foundation, 1.3 feet above ground, aluminum tablet stamped "698 ADJ 1905"	698.173
T. 44 N., R. 11 E., sec. 16, Libertyville, Chicago, Milwaukee and St. Paul railroad station, in front of; top of rail	692.4
T. 44 N., R. 11 E., sec. 4, west quarter corner, 0.2 mile east of; T road west, on east side of road, opposite T, on line with east and west fence line, 1.2 feet west of fence and 45 feet south of telegraph pole, iron post stamped "660 ADJ 1905"	659.431
T. 45 N., R. 11 E., sec. 32, in northwest quarter of; T road south, southeast corner of, on east side of road, 2.1 feet west of old fence line and 21 feet south of new east and west fence line, iron post stamped "766 ADJ 1905"	765.949
T. 45 N., R. 11 E., sec. 20, east quarter corner of; cross roads, at northwest corner of; in school yard, on north side of road inside of fence line, 1 foot north of fence and 4.2 feet west of fence corner, at southeast corner of schoolyard, iron post stamped "760 ADJ 1905"	759.773
T. 45 N., R. 11 E., sec. 5, east quarter corner of; cross roads at northeast corner, on north side of road, 40 feet east of fence corner, 1 foot south of fence, iron post stamped "720 ADJ 1905"	719.437
T. 46 N., R. 11 E., sec. 29, north quarter corner of; cross roads, southeast corner of; east side of road, 20 feet south of fence corner, 1.2 feet west of fence, iron post stamped "713 ADJ 1905"	762.518
T. 46 N., R. 11 E., sec. 16, center of; cross roads at Rosecrans, at northwest corner of; on north side of road, 1 foot south of fence, 11 feet west of fence corner, iron post stamped "722 ADJ 1905"	722.230
T. 46 N., R. 11 E., sec. 15, near center of; crossing of Chicago, Milwaukee and St. Paul R. R., top of rail	697.8
T. 46 N., R. 11 E., sec. 14, east quarter corner of; cross roads, at southeast corner, on east side of road and 8 feet south of fence corner, iron post stamped "701 ADJ 1905"	700.974
T. 46 N., R. 11 E., sec. 13, west quarter corner, 0.3 mile east of; crossing of Chicago and North Western Railroad, top of rail	695.8
T. 46 N., R. 12 E., sec. 18, 0.3 mile west of; cross roads, at northwest corner of; on north side of road (on bank), 2.3 feet south of old board fence, and 14.5 feet west of east line of fence, iron post stamped "714 ADJ 1905"	713.751
T. 46 N., R. 12 E., sec. 21, Zion City, crossing of Chicago and North Western Railroad, top of rail	630.3
T. 46 N., R. 12 E., sec. 21; southeast corner of; cross roads at Lake Mound Cemetery, Zion City, southeast corner of cross roads, east of road, 1 foot west of cemetery fence, iron post stamped "638 ADJ 1905"	632.519
T. 45 N., R. 12 E., sec. 4, southeast corner, 0.2 mile west of; T road to west, at southwest corner of T, south side of road, 1.2 feet north of fence, 9 feet west of fence corner, iron post stamped "647 ADJ 1905"	646.570
T. 45 N., R. 12 E., sec. 16, east quarter corner, 0.3 mile west of T. road to west, northwest corner of T, top of fire plug, Sheridan road and Glen Flora avenue	642.970
Waukegan, northeast corner stone window sill, in east front of Lake county court house city B. M., no marks	664.115
Waukegan, T. 45 N., R. 12 E., sec 21, Lake county court house; east entrance, in stone base of two columns, on north side of entrance, aluminum tablet stamped "669 ADJ 1905"	668.387
T. 45 N., R. 12 E., sec. 4, northwest quarter of; 18th st. station, Chicago, Milwaukee Electric R. R., Elgin, Joliet and Eastern R. R. bridge over Chicago and North Western, C. & M. Electric R. R. and wagon road, west abutment wall, in top of projection of bottom course masonry, 4.2 feet north of south end of wall and 1.5 feet above pavement, aluminum tablet stamped "659 ADJ 1905"	658.935

Feet.

T. 44 N., R. 12 E., sec. 20, Lake Bluff, Chicago and North Western R. R. bridge over wagon road and Chicago and Milwaukee Electric road, south of station, in top of stone foundation wall supporting iron column, between Electric road (Libertyville branch), and wagon road, in top of wall, 3 feet northwest of southeast end of, aluminum tablet stamped "671 ADJ 1905" 670.778

T. 44 N., R. 12 E., sec. 33, Lake Forestry, at southwest corner of city hall grounds, iron post stamped "Prim. Trav. Post No. 12," "713 ADJ 1905" 712.913

Primary Leveling.

DU PAGE COUNTY—WHEATON QUADRANGLE.

The elevations in the following list depend on bench marks established at Bartlett and Roselle by U. S. Army engineers, their accepted values as determined by the 1902 adjustment being 804.035 feet and 772.136 feet, respectively.

The leveling was done in 1905 by Mr. R. C. Howard, under the direction of Mr. Albert Pike, topographer.

Wheaton Quadrangle.

BARTLETT SOUTH BY ROAD TO WEST CHICAGO, THENCE EAST BY CHICAGO AND NORTHWESTERN RAILWAY TO GLEN ELLYN, THENCE NORTH ALONG HIGHWAY AND CHICAGO AND GREAT WESTERN RAILWAY TO ROSELLE.

Feet.

Bartlett, U. S. A. Engineers B. M. No. 89, 150 meters northwest of station; 100 meters north of Chicago, Milwaukee and St. Paul railway track, in stone foundation of Congregational church, center of copper bolt leaded horizontally on east face of southeast corner.... 804.035

T. 40 N., R. 9 E., near northeast corner sec. 9, stone bridge over small stream, aluminum tablet stamped "787 ILLINOIS 1905" (in east wall, southeast corner) 787.399

T. 40 N., R. 9 E., corner secs. 27, 28, 33 and 34, 0.25 mile west of; Ingleton school house, south wall, southwest corner, aluminum tablet stamped "795 ILLINOIS 1905" 794.817

West Chicago, City Hall, east wall, 2 feet from southeast corner, aluminum tablet stamped "784 ILLINOIS 1905"..... 784.058

Winfield, 150 feet east of station; 75 feet south of C. & N. W. Ry., stone culvert, east side of road, aluminum tablet stamped "727 ILLINOIS 1905" 726.647

Wheaton, court house, north side of west entrance, aluminum tablet stamped "753 ILLINOIS 1905" 752.858

Glen Ellyn, high school, north wall, 6 feet west of entrance, aluminum tablet stamped "766 ILLINOIS 1905" 766.038

Bloomingdale, Kolbusch & Hauseminn store building, west wall, 35 feet south of north wall, aluminum tablet stamped "771 ILLINOIS 1905" 771.107

GLEN ELLYN SOUTH ALONG HIGHWAYS TO LISLE, THENCE WEST AND NORTH BY NAPERSVILLE AND WARRENHURST TO WEST CHICAGO.

T. 39 N., R. 10 E., sec. 35, near southwest corner northwest quarter of; west side, south abutment, small bridge, aluminum tablet stamped "697 ILLINOIS 1905" 697.482

Lisle, 0.2 mile west of; C. B. & I. Ry. bridge over east branch Du Page river, east abutment, north side, aluminum tablet stamped "697 ILLINOIS 1905" 674.449

Naperville, in front of station; top of south rail..... 715.5

Naperville, Nicholas Library building, southwest corner VanBuren ave. and Washington st., west wall, northwest corner, aluminum tablet stamped "693 ILLINOIS 1905" 693.290

	Feet.
T. 38 N., R. 9 E., sec. 16, near southeast corner of northeast quarter; rock culvert, east abutment, north side, aluminum tablet stamped "697 ILLINOIS 1905"	697.291
Warrenhurst, 275 feet E. of railway track, 50 feet north of road, Daw Bros. house, south wall, rock foundation, 10 feet west of southeast corner, aluminum tablet stamped "732 ILLINOIS 1905"	732.308

Primary Leveling.

Mason, Menard, Logan and Sangamon Counties—Havana, Petersburg and Springfield Quadranles.

The elevations in the following list depend on bench mark established by U. S. Army engineers at Havana, Ill., at south end of east pier of highway bridge over Illinois river, three feet from west side. Top of copper bolt, its value corrected to 1903 adjustment being 451.326 feet. A double rodded line was run over the Chicago, Peoria & St. Louis Railway to Athens; the balance of the leveling was run in circuits with a single rod.

The leveling was done in 1905 by Mr. C. R. Howard, under the direction of Mr. Albert Pike, topographer.

Havana Quadrangle.

HAVANA ALONG CHICAGO, PEORIA AND ST. LOUIS RAILWAY TO ATHENS.

(Double rodded line.)

	Feet.
Havana, Army Engineers B. M., iron highway bridge over Illinois river, on top of south end of east pier, top of copper bolt 3 feet from west side of pier	451.326

Petersburg Quadrangle.

Long Branch, 255 feet south of engine room of grain elevator, in west wall, 5.4 feet north of south wall, 4.6 feet south of north wall, 5.5 feet above ground, aluminum tablet stamped "498 ADJ 1905"	491.247
Kilbourne, in front of station; mail line, top of east rail	494.
Kilbourne, McFaddens Elevator, in north side of northwest foundation pillar, aluminum tablet stamped "502 ADJ 1905"	495.531
Oakford, C. Lutz's store, in west wall brick foundation, 2 feet from southwest corner, aluminum tablet stamped "502 ADJ 1905"	495.125
Aterbury, W. C. Koppleen's grain elevator, northwest corner of rock foundation, aluminum tablet stamped "609 ADJ 1905"	601.730
Hill, top east of rail main line, in front of station	603
Petersburg, in front of station; top of east rail	505.5
Petersburg, Menard county court house, north wall, 2 feet east of entrance, 4 feet above ground, aluminum tablet stamped "531 ADJ 1905"	523.672

Springfield Quadrangle.

Tice, school house, west side brick foundation, 12 feet east of, north side, aluminum tablet stamped "617 ADJ 1905"	610.477
Tice, in front of station; top of north rail	616.
Athens, city hall, west wall, on water table, aluminum tablet stamped "613 ADJ 1905"	605.749

ATHENS ALONG CHICAGO, PEORIA AND ST. LOUIS RAILWAY TO SPRINGFIELD.

	Feet.
Cantrall, in front of station; top of north rail	589.
Cantrall, Cantrall Coöperative Coal Co.'s store, in water table, east side of building, 3 feet north of south side, aluminum tablet stamped "603 ADJ 1905"	596.147
Dunlap school house, north wall, brick foundation, 2 feet from east wall, aluminum tablet stamped "591 ADJ 1905"	583.736
Andrews, 0.5 mile north of; spike in west side of milepost "P80-47"	582.127
Andrews, in front of station; top of west rail	583.82
Ridgley, opposite milepost St. Louis 87 miles, top of east rail	593.53

(LINE LEAVES RAILROAD, FOLLOWS PEORIA ROAD.)

Springfield, postoffice, water table, east side, 12 feet from southeast corner, aluminum tablet stamped "606 ADJ 1905"	598.963
Springfield, City B. M. southwest entrance court house grounds, in stone post marked "City B. M. 58.44," top of copper bolt	598.285

SPRINGFIELD EAST AND NORTH ALONG HIGHWAY VIA. RIVERTON TO WILLIAMSVILLE, THENCE WEST AND SOUTH TO CANTRALL.

T. 16 N., R. 4 W., near center sec. 21, in west wall of brick foundation to church, aluminum tablet stamped "583 ADJ 1905"	576.416
Riverton, opera house, T. 16 N., R. 5 W., near southeast corner sec. 9, south side, southeast corner stone threshold opera house, aluminum tablet stamped "560 ADJ 1905"	552.762
T. 17 N., R. 5 W., 0.25 mile east of; center line between secs. 32 and 33, iron highway bridge over fork of Wolf creek, east abutment, southwest corner, aluminum tablet stamped "535 ADJ 1905"	528.390
T. 17 N., R. 5 W., near center of east half sec. 20, Locust Lane school house, west wall brick foundation, aluminum tablet stamped "585 ADJ 1905"	578.398
T. 17 N., R. 5 W., near center sec. 4, Williamsville, east wall of Praters bank, aluminum tablet stamped "613 ADJ 1905"	605.615
T. 18 N., R. 6 W., sec. 35, on south line of; north side of road, Fred VanMenner's house, in west wall of foundation, aluminum tablet stamped "598 ADJ 1905"	591.313
T. 17 N., R. 6 W., corner secs. 8, 9, 16 and 17, 0.25 mile north of; Cantrall Coöperative Coal Co.'s store, east side of water-table table, aluminum tablet stamped "603 ADJ 1905"	596.087

Primary Leveling.

CHAMPAIGN AND PIATT COUNTIES—MAHOMET AND URBANA QUADRANGLES.

The elevations in the following list depend on a bench mark established by precise line of levels of 1905 at Champaign, 53 feet southeast of southeast corner of Engineering Building, University of Illinois, iron post stamped "Prim. Trav. Sta. No. 1," its accepted elevation being 721.050 feet. For additional elevations refer to precise leveling.

The leveling was done in 1905 by Mr. R. C. Howard, levelman, under the direction of Mr. Albert Pike, topographer.

URBANA QUADRANGLE.

URBANA ALONG HIGHWAY SOUTH AND EAST TO PHILO.

	Feet.
Champaign, University of Illinois, southeast corner of Engineering Hall, iron post stamped "Prim. Trav. Sta. No. 1 F"	721.050
T. 18 N., R. 9 E., northwest corner sec. 6; southeast angle of cross roads, iron post stamped "717 ILLINOIS 1905"	717.873
T. 18 N., R. 9 E., southwest corner sec. 17, north side, east abutment bridge, aluminum tablet stamped "680 ILLINOIS 1905"	680.292
Philo, Philo Exchange Bank, east side water table, 12 feet south of wall, aluminum tablet stamped "737 ILLINOIS 1905"	737.780

PHILO ALONG HIGHWAY EAST AND NORTH TO ST. JOSEPH, THENCE WEST TO URBANA.

Sidney, high school, south side, southwest corner, aluminum tablet stamped "673 ILLINOIS 1905"	672.523
T. 19 N., R. 10 E., corner secs. 27, 28, 33 and 34, 0.25 mile east of; south abutment, west side iron bridge over Salt river, aluminum tablet stamped "655 ILLINOIS 1905"	655.051
T. 19 N., R. 10 E., northeast corner sec. 15, 0.6 mile west of St. Joseph, west abutment north side bridge over Salt river, aluminum tablet stamped "663 ILLINOIS 1905"	662.649
Mayview station, 0.1 mile east of; T. 19 N., R. 10 E., sec. 8, southwest corner of; southwest corner intersection road, concrete right of way post marked "P. & E. property line," west side post, alum-	
Mayview, in front of station; top of north rail	686
inum tablet stamped "681 ILLINOIS 1905"	680.662

ST. JOSEPH NORTH ALONG HIGHWAY TO SECTION 2, T. 20 N., R. 10 E., THENCE WEST ON TOWNSHIP LINE TO SEC. 6, T. 20 N., R. 9 E., THENCE SOUTH TO CHAMPAIGN.

T. 20 N., R. 10 E., near center line between secs. 22 and 23, B. F. Youman's house, west of road, in south wall, brick foundation, aluminum tablet stamped "676 ILLINOIS 1905"	675.960
T. 20 N., R. 10 E., secs. 2, 3, 10 and 11, 0.25 mile south of corner, east of road, Henry Dintsman's house, south side, brick foundation aluminum tablet stamped "677 ILLINOIS 1905"	677.393
T. 21 N., E. 10 E., southwest corner sec. 32, west side, north abutment bridge, aluminum tablet stamped "688 ILLINOIS 1905"	687.516
T. 20 N., R. 9 E., northwest corner sec. 6, north of road, south side of J. W. Jane's house, brick foundation, aluminum tablet stamped "748 ILLINOIS 1905"	748.134
T. 20 N., R. 9 E., sec. 18, 0.5 mile south of northwest corner of; west side, north abutment bridge, aluminum tablet stamped "728 ILLINOIS 1905"	727.693

MAHOMET QUADRANGLE.

NEAR CHAMPAIGN WEST OVER ILLINOIS CENTRAL RAILWAY TO NEAR SEYMOUR, THENCE ALONG HIGHWAYS TO SOUTHWEST CORNER OF SEC. 7, T. 18 N., R. 7 E., THENCE EAST TO SOUTHWEST CORNER OF SEC. 12, T. 18 N., R. 8 E.

Staley, in front of station; top of north rail	740.596
T. 19 N., R. 8 E., southwest corner sec. 9, northwest corner road, iron post stamped "734 ILLINOIS 1905"	734.372
Bondville, in front of station; top of north rail	716.219
Bondville, 300 feet east of station; 50 feet north of track, iron post stamped "717 ILLINOIS 1905"	716.685
Seymour, in front of station; top of north rail	698.965
Seymour, 100 feet west of station; north side right of way, iron post stamped "698 ILLINOIS 1905"	697.597
T. 19 N., R. 7 E., southwest corner sec. 18, north of road, iron post stamped "707 ILLINOIS 1905"	706.962
T. 19 N., R. 7 E., southwest corner sec. 31, southwest corner of road, iron post stamped "708 ILLINOIS 1905"	708.286

	Feet.
T. 18 N., R. 7 E., southwest corner sec. 7, northwest corner road, iron post stamped "702 ILLINOIS 1905"	702.187
T. 16 N., R. 7 E., southwest corner sec. 10, northeast angle of cross roads, intersection, iron post stamped "692 ILLINOIS 1905"	691.839
T. 18 N., Rs. 7 and 8 E., southwest corner sec. 7, southwest corner of road, iron post stamped "690 ILLINOIS 1905"	690.286
T. 18 N., R. 8 E., southwest corner sec. 10, northwest corner of road, southwest corner school yard, iron post stamped "728 ILLINOIS 1905"	728.421

MAHOMET EAST ALONG HIGHWAY TO SOUTHWEST CORNER SEC. 7, T. 20 N., R. 9 E.

Mahomet, 230 feet west of station; 15 feet north of track, iron post stamped	712.064
T. 20 N., R. 7 E., and 8 E., secs. 13 and 18, north of road, iron post stamped "747 ILLINOIS 1905"	747.153
T. 20 N., R. 8 E., sec. 10, southwest corner of; northeast corner of road, iron post stamped "772 ILLINOIS 1905"	772.468

Primary Leveling.

BOND, MADISON AND ST. CLAIR COUNTIES—BELLEVILLE AND BREESE QUADRANGLES.

The elevations in the following list depend on an aluminum tablet set in 1903 in west abutment of Baltimore & Ohio Railroad bridge 0.25 mile east of Caseyville, stamped "449," the elevation of which is accepted as 449.160 feet.

All bench marks are stamped "Illinois ADJ" in addition to figures of elevation.

The leveling on the Belleville quadrangle was done by Mr. C. S. Blair, levelman, and of the Breese quadrangle by Mr. C. F. Wood, levelman, both in 1905 under the direction of Mr. W. J. Lloyd, topographer.

NEAR CASEYVILLE VIA BALTIMORE AND OHIO RAILROAD TO RIDGE PRAIRIE, THENCE ALONG HIGHWAYS SOUTH TO BELLEVILLE, EAST TO 4 MILES EAST OF GRASSLAND, NORTH TO SUMMERFIELD AND WEST ALONG BALTIMORE AND OHIO RAILROAD TO RIDGE PRAIRIE.

	Feet.
Caseyville, 0.25 mile east of, in west abutment railroad bridge, aluminum tablet stamped "449, A D J"	449.160
Ridge Prairie, at southwest corner of road crossing, 0.25 mile east of Furmans, 20 feet south of track, iron post stamped "564, A D J"	563.164
Belleville, northeast corner of court house yard, iron post stamped "Prim. Trav. Sta. No. 15, A D J 531"	530.682
Grassland, 100 feet east of, 200 feet south of station, iron post stamped "Prim. Trav. Sta. No. 16, 435 A D J"	434.306
Grassland, 4 miles east of, northeast corner or road crossing, southwest corner of field of J. B. Freeze, iron post stamped "Prim. Trav. Sta. No. 17, 469 A D J"	468.778
Summerfield, schoolhouse, southeast corner of, aluminum tablet stamped "Prim. Trav. Sta. No. 18, 478 A D J"	478.074
Lebanon, stone step, just west of main entrance to St. Joseph's church, aluminum tablet stamped "467 A D J"	466.296
O'Fallon, southwest corner of brick platform, at B. & O. station, iron post stamped "551 A D J"	550.520

NEAR CASEYVILLE VIA VANDALIA LINE TO ST. JACOBS, THENCE SOUTH ALONG HIGHWAY TO SUMMERVILLE.

	Feet.
Collinsville, at northwest corner of road crossing, just west of station, opposite saloon of Schmacker Bros., iron post stamped "474, A D J"	472.974
Formosa, northeast corner of stone platform, iron post stamped "571, A D J"	570.155
Troy, 100 feet north of, northwest corner of station, iron post stamped "549, A D J"	548.626
St. Jacobs, 0.25 mile west of, south side of stone bridge, aluminum tablet stamped '506, A D J"	504.883
Summerfield, 3.5 miles north of, at southwest corner of junction, 30 feet west of cottonwood, iron post stamped "507, A D J"	506.257

BREESE QUADRANGLE.

FOUR MILES EAST OF GRASSLAND, EAST AND ALONG HIGHWAYS TO GERMANTOWN, THENCE WEST ALONG BALTIMORE AND OHIO RAILROAD TO SUMMERFIELD.

New Baden, in bank building, aluminum tablet stamped "463 A D J"	462.069
Albert, in Louis Foytman's house, second one north of railroad, west side of street, aluminum tablet, stamped "445, A D J"	444.477
Germantown, Boniface's school, in northeast corner, aluminum tablet stamped '433, A D J"	432.236
Breese, in northwest corner of St. Dominic school building, tablet stamped "458, A D J"	458.120
Aviston, east side of entrance, south side of brick Catholic church, tablet stamped "475, A D J"	474.385
Trenton, in southeast corner of city hall, tablet stamped "489, A D J".	497.606

ST. JACOBS VIA VANDALIA LINE TO HIGHLAND, THENCE EAST AND SOUTH ALONG HIGHWAYS VIA SEBASTOPOL TO BREESE.

Highland, in First National Bank, aluminum tablet stamped "545, A D J"	544.680
Sebastopol, in south side of old brick school building, aluminum tablet stamped "545, A D J"	545.325
St. Rose, in north side of Catholic church, in door sill, aluminum tablet stamped "504, A D J"	503.977
Breese, 3.5 miles north of, in east side of house of August Lager, aluminum tablet stamped "473, A D J"	472.934

PRIMARY LEVELING.

CARMI, ELDORADO, ENFIELD AND NEW HAVEN QUADRANGLES—GALLATIN, HAMILTON, SALINE AND WHITE COUNTIES.

The elevations in the following list are based upon the unadjusted precise level line of 1906, Duquoin to Shawneetown, which recovered the standard bench mark of this list at Eldorado and primary leveling in Indiana brought from Vincennes, Indiana, corrected on account of a connection obtained through Ohio River Survey precise leveling of 1906. The elevations accepted at Duquoin, Illinois, and Vincennes, Indiana, are by precise leveling of the U. S. Coast and Geodetic Survey corrected in accord with the adjustment of 1903.

All bench marks are stamped "A D J" in addition to the figures of elevation.

The leveling was done in 1905 under the direction of Mr. W. J. Lloyd, topographer, by Mr. C. B. Blair, levelman.

Carmi Quadrangle.

NEAR GRAYVILLE, SOUTHEAST OVER CAIRO DIVISION OF CLEVELAND, CINCINNATI, CHICAGO AND ST. LOUIS RAILROAD NEAR STOKES.

	Feet.
Carmi, west side of main entrance in stone step of First Presbyterian Church, aluminum tablet stamped "399"	398.806
Brownsville, southwest corner of stone platform, iron post stamped "417 ADJ"	416.487

SOLITUDE, INDIANA, WEST TO LITTLE CHAIN, ILLINOIS.

Mannie, U. S. A. Engineer B. M. No. 32, on top of coping of Louisville & Nashville railroad bridge, down stream end of Indiana land pier, 1 foot from edge of coping, chiseled circle (Eng'r elev. 370.471)	373.264

Enfield Quadrangle.

STOKES OVER CAIRO DIVISION OF CLEVELAND, CINCINNATI, CHICAGO AND ST. LOUIS RAILWAY TO NORRIS CITY.

Stokes, southeast corner of yard of J. Pyles' store, iron post stamped "415 ADJ"	414.287

Eldorado Quadrangle.

NORRIS CITY ALONG HIGHWAYS WEST AND SOUTH TO BROUGHTON, THENCE ALONG LOUISVILLE AND NASHVILLE RAILROAD TO ELDORADO, THENCE ALONG HIGHWAY EAST TO RIDGEWAY, THENCE NORTH TO OMAHA, THENCE OVER BALTIMORE AND OHIO RAILROAD TO NORRIS CITY.

Norris City, stone sill, at main entrance north side of Cumberland Presbyterian Church, aluminum tablet stamped "444 ADJ"	443.520
Norris City, 3.5 miles west of; at northeast corner of Jennings school house, iron post stamped "410 ADJ"	409.696
Broughton, 3 miles north of; southeast corner of forks of road, iron post stamped "371 ADJ"	370.857
Broughton, northeast corner of cinder platform of L. & N. depot, iron post stamped "379 ADJ"	378.340
Francis Mill, northeast corner of cinder platform, iron post stamped "371 ADJ"	370.780
Eldorado, 10 feet south of southwest corner of Grand Hotel; iron post stamped "388 ADJ"	387.568
Eldorado, 3.5 miles east of; at jog in road, 3 feet northeast of oak tree in middle of road, iron post stamped "373 ADJ"	372.849
Zion Church, front wall, northeast corner, aluminum tablet stamped "390 ADJ"	389.546
Ridgeway, stone foundation of Catholic Church, southeast corner, east of front entrance, aluminum tablet stamped "377 ADJ"	376.784
Omaha, 90 feet south of station; 12 feet east of track, iron post stamped "367 ADJ"	366.765
Middlepoint, at northeast corner of cinder platform, iron post stamped "433, A D J"	432.570
Omaha, 3 miles east of, southwest angle of forks with road running south, iron post stamped "405 A D J"	404.968

New Haven Quadrangle.

NEAR NORRIS CITY, EAST ALONG HIGHWAY TO LITTLE CHAIN.

Iron, northeast corner of junction, 5 feet west of southwest corner of warehouse, iron post stamped "463 A D J"	462.707
Herald, 3 feet east of northeast corner of school house, iron post stamped "430 A D J"	429.727

Feet.

Emma, southeast corner of junction, 0.5 mile south of, iron post stamped "366, A D J'" 365.821
Little Chain, 1 mile west of, southwest corner of road forks, iron post stamped "367, A D J" 366.480

NEAR EMMA SOUTH ALONG HIGHWAY TO INMAN AND WEST TO NEAR RIDGEWAY.

New Haven, at northeast corner of Scudmore and Mathia bank, aluminum tablet stamped "370, A D J" 369.885
Inman, southeast corner of forks or roads, 0.5 mile east of, iron post stamped "379, A D J" 378.012

NEAR OMAHA EAST ALONG HIGHWAY TO NEW HAVEN.

Omaha, 6.5 miles east of, northeast corner of junction with road running south, 12 feet west of hickory, 2 feet diameter, iron post stamped "387, A D J" 386.758

NEW HAVEN EAST ALONG HIGHWAY TO WABASH.

Ragland Island, 1.5 miles south of (Engineer's B. M. No. 38), just above Loop Slough, 75 feet south of large high water barn, iron pipe marked "U. S. Eng'r B. M." (Engr's elev. 343.802) 345.83
Ragland Island, 1.5 miles south of, 75 feet south of barn, 3 feet east of Engineers' B. M., iron post stamped "346, A D J" 345.716

ST. PATRICK'S CHURCH EAST AND SOUTH TO ROUND POND SCHOOL HOUSE, THENCE NORTH TO WABASH RIVER.

Church, 0.75 mile south of, nrotheast corner of junction, iron post stamped "366, A D J" 365.666
Round Pond, northeast corner of school house, iron post stamped "362, A D J" 361.923

PRIMARY LEVELING.

Prior to Coöperation.

	QUADRANGLES.	COUNTIES.
List 1.	Cordova.	Whiteside, Henry, Rock Island.
List 2	Danville.	Vermilion.
List 3	Peoria.	Peoria and Tazewell.
List 4	Claremont and Mt. Carmel.	Edwards and Wabash.
List 5	East St. Louis.	Madison and St. Clair.

Primary Leveling.

CORDOVA QUADRANGLE—WHITESIDE, HENRY AND ROCK ISLAND COUNTIES.

The elevations in the following list are based on the Mississippi River Commission bench mark at Albany, a copper bolt in the west side of the southwest corner of foundation of brick store occupied by Hopper & Son, and marked "U. S. P. B. M." The elevation of this bench mark, which was accepted as the central datum point for leveling in this locality, is 595.876 feet above mean sea level by the 1903 adjustment. The leveling was done in 1896 by Mr. G. W. Newell, levelman, under the direction of Mr. R. C. McKinney, topographer.

CORDOVA QUADRANGLE.

WHITESIDE COUNTY, ALBANY TOWNSHIP.

	Feet.
T. 20 N., R. 2 E., sec. 1, fourth principal meridian, half section line; on south line, iron post stamped "678"	679.483

WHITESIDE COUNTY, NEWTON TOWNSHIP.

T. 20 N., R. 3 E., sec. 2, near northeast corner of southeast quarter of northeast quarter of; junction of roads on east line of section; iron post stamped "702"	703.496

WHITESIDE COUNTY, ERIE TOWNSHIP.

Erie, small triangular park in public square, iron post stamped "587"	588.345

HENRY COUNTY, PHOENIX TOWNSHIP.

T. 18 N., R. 3 E., sec. 12, northwest corner of northeast quarter of northwest quarter, junction of roads, 0.25 mile west of Sharon postoffice; iron post stamped "597"	598.234

HENRY COUNTY, LORAINE TOWNSHIP.

T. 18 N., R. 4 E., sec. 6, near southeast corner of, junction of roads at William Ornett's (Sharon Stock Farm); iron post stamped "627"	628.138

ROCK ISLAND COUNTY, ZUMA TOWNSHIP.

Joslyn, northeast corner W. H. Whiteside's yard, by Chicago, Burlington and Quincy Railroad; iron post stamped "581"	582.253
T. 19 N., R. 2 E., sec. 23, southeast corner of; iron post stamped "679"	680.336
Fenton, south side of sidewalk, about 100 feet west of Chicago, Burlington and Quincy Railroad, iron post stamped "621"	602.368

ROCK ISLAND COUNTY, COE TOWNSHIP.

Hillsdale, 90 feet east of north end of Chicago, Burlington and Quincy Railroad station; iron post stamped "598"	578.156

PRIMARY LEVELING.

DANVILLE QUADRANGLE—VERMILION COUNTY.

The elevations in the following list were originally based on the elevation of the Chicago & Eastern Illinois Railroad, in front of depot at Danville Junction, 613.5 feet above mean sea level. Dependent on this, the central datum tablet, placed in the postoffice building, is stamped "DNVL 603." In 1906 the bench mark at Catlin was connected with the precise level line run from Olney via Fairmount to Champaign, the bench mark at the latter place having been established in 1905 by the precise level line run from Pekin. A correction of -1.078 feet has been applied to original elevations on the Danville quadrangle to reduce them to mean sea level as determined from the line from Pekin.

Bench marks set in 1897 are stamped "DNVL" in addition to figures of the elevations.

The leveling was done in 1897 by Mr. John L. McCalman, levelman, under the direction of Mr. R. C. McKinney, topographer.

DANVILLE QUADRANGLE.

	Feet.
Danville Junction, in front of station, railroad crossing, top of rail	612.4
Danville, in front of Chicago and Eastern Illinois R. R. station, top of rail	597.1
Danville, in front of station of Wabash Railroad, top of rail	597.7
Danville, in front of Chicago, Cleveland, Cincinnati and St. Louis Railroad station; top of rail	604.2
Danville, postoffice building, east face of north balustrade, 1.5 feet above sidewalk, bronze tablet stamped "DNVL 603"	601.448
Danville, courthouse, just south of step to west entrance, second course above sidewalk, bronze tablet stamped "DNVL 604"	602.718
Westville, T. 18 N., R. 11 W., sec. 5, southwest corner of; iron post stamped "DNVL 672"	671.012
T. 19 N., R. 11 W., sec. 27, in north half of; floor of bridge over Vermilion river, on Grape creek road	532.4
Catlin, T. 19 N., R. 12 W., sec. 34, near center of; iron post stamped "DNVL 658"	657.345
T. 20 N., R. 10 W., sec. 18, quarter corner east side of; on State line; iron post stamped "DNVL 720"	718.866
T. 20 N., R. 11 W., sec. 11, northeast corner of; rock at section corner	698.2
T. 20 N., R. 11 W., sec. 17, quarter corner north side of; iron post stamped "DNVL 655"	654.033
T. 20 N., R. 12 W., sec. 35; southwest corner of; iron post stamped "DNVL 649"	647.982

PRIMARY LEVELING.

PEORIA QUADRANGLE—PEORIA AND TAZEWELL COUNTIES.

The elevations in the following list are based upon an aluminum tablet in the west side of Bradley Polytechnic Institute building, Peoria, Ill., stamped "607 PEORIA," the elevation of which is determined to be 607.691 feet above mean sea level.

The initial points from which the corrected elevations have been obtained are the standard bench marks at Pekin and Mackinaw river bridge which have been recovered by the recent precise level lines of the army engineers along the Illinois river. The correction applied at Pekin to the "Memphis" datum, the datum upon which the engineers' figures are based, is -6.95 feet, an interpolated correction to accord with the "1903 adjustment."

The leveling was done in 1902 under the direction of Mr. Chas. E. Cooke, topographer, by Mr. Carleton McRae, levelman.

Standard bench marks set in the course of this work are stamped with the letters "PEORIA" in addition to the figures of the elevation, mostly one foot lower than the corrected values.

PEORIA WEST ALONG FARMINGTON ROAD 7 MILES, THENCE SOUTH 4 MILES, THENCE EAST TO HOLLIS, THENCE NORTHEAST TO PEORIA.

	Feet.
Peoria, water gauge at foot of Bridge street; gauge mark reading 130′ below Lake Michigan	451.36
Peoria, Bradley Polytechnic Institute, in west side of; aluminum tablet stamped "607 PEORIA"	607.541
Peoria, 7 miles west of; at cross roads, north limestone M. E. Church, in middle of west foundation, bronze table stamped "708 PEORIA"	708.675
Hollis township, on line between sections 4 and 5 200 yards west of north and south road, 300 yards north of T road to east, in northwest corner of foundation of C. F. Goetze house, aluminum tablet stamped "622 PEORIA"	622.654

PEORIA TO POINT 25 MILES EAST OF UPPER FREE BRIDGE, THENCE SOUTH TO FARMINGDALE, THENCE WEST TO PEORIA.

Peoria, 6.25 miles northeast of; 2.5 miles east of Free Bridge, house of J. Grosenbach, water tank at foundations of, east side of, bronze tablet stamped "693 PEORIA"	693.746

FARMINGDALE SOUTH TO GROVELAND, THENCE WEST TO PEKIN.

Groveland, southwest corner of Baptist Church, aluminum (?) tablet stamped "778 PEORIA"	778.710

HOLLIS SCHOOL NO. 4 SOUTH TO MAPLETON, THENCE EAST TO PEKIN, THENCE NORTH TO HOLLIS STATION, THENCE RETURN TO PEKIN.

Mapleton, 2 miles east of; cross cut in east wing of south abutment of steel wagon bridge over Big LaMache Creek	455.33
Pekin, Catch Basin, in northeast corner of county clerk's office, in court house grounds, aluminum (?) tablet stamped "478 PEORIA". (Elevation by Army Engineers, 485.973 Memphis datum.)	479.023

PEKIN SOUTHWEST ALONG RIVER ROAD TO MACKINAW RIVER BRIDGE, THENCE SOUTH 4 MILES, THENCE EAST TO NEAR HAWLEY, THENCE NORTH TO PEKIN.

Mackinaw river bridge, iron, on south wing of west abutment, aluminum (?) tablet stamped "453 PEORIA" (Elevation by Army Engineers, 461.205, Memphis datum.)	454.255
Hawley station, 0.65 miles east of; on southeast wing of abutment of wagon bridge over north and south road, aluminum tablet stamped "513 PEORIA"	513.744

HAWLEY NORTHEASTERLY TO GROVELAND.

Hawley, 1 mile south and 0.5 mile east of; iron bridge over small branch, south wing of east abutment, aluminum tablet stamped "511 PEORIA"	511.521
Groveland, 6 miles south of; 1.5 miles west of Tremont, wagon bridge on east west road, east abutment, north wing, aluminum tablet stamped "611 PEORIA"	612.127

Primary Leveling.

CLAREMONT AND MT. CARMEL QUADRANGLES—EDWARDS AND WABASH COUNTIES.

The elevations in the following list are based upon bench mark A3 of the U. S. Coast and Geodetic Survey transcontinental precise level line at Vincennes, Ind., the elevation of which is accepted as 433.445 feet above mean sea level. The work in this locality is extended from the adjoining work in Indiana, adjusted also in accord with elevations brought by precise leveling of 1906 from Duquoin, Ill.

The leveling was done in 1902 under the direction of Mr. Chas. W. Goodlove, topographer, by Mr. H. G. Lowe, levelman.

Standard bench marks set in the course of this work are stamped with the letters "VIN" in addition to the figures of elevation.

Mt. Carmel Quadrangle.

GRAYVILLE NORTHEAST ALONG BIG FOUR RAILROAD VIA COWLING, KEENSBURG AND SCHRODT'S STATION TO MT. CARMEL.

	Feet.
Grayville, at milepost E 32, at northwest corner of bridge 289, head of bolt	386.66
Grayville, 100 feet south of station; 6 feet east of track, iron post stamped "392 VIN"	392.413
Cowling, T. 2 S., R. 14 W., Big Four Station; northeast corner of; 8 inches north from, 6 inches above ground, iron post stamped "397 VIN"	397.206
Keensburg, T. 2 S., R. 14 W., northwest corner of M. E. church (frame), in face of foundation wall on north side, aluminum tablet stamped "430 VIN"	430.172
Sugar creek (Schrodts) T. 1 S., R. 13 W., at northeast corner of Peter Schrodts store, 1 foot north, iron post stamped "458 VIN".	458.566
Mt. Carmel court house, at southwest side, in southeast wing, on west sill wall, bronze tablet stamped "465 VIN"	464.860
The above bench mark is not directly connected by leveling with other bench marks of this list, but is determined by a checked line from Princenton, Indiana.	

MT. CARMEL (JUNCTION ON BIG FOUR AND SOUTHERN RAILWAYS), WEST ALONG SOUTHERN RAILWAY VIA MAUD TO BELLMONT.

Maud, T. 1 S., R. 13 W., northeast corner of Christian church, east side in face of foundation wall of, bronze tablet stamped "442 VIN".	441.884

KEENSBURG NORTHWEST TO BELLMONT, THENCE WEST ALONG SOUTHERN RAILWAY TO BROWNS.

Bellmont, T. 1 S., R. 14 W., town hall, at southwest corner on south side, in face of wall, 3 feet above ground, aluminum tablet stamped "431 VIN"	431.346
Browns, T. 1 S., R. 14 W., in southeast corner of red brick M. E. Church, in face of south wall, 3 feet above ground, aluminum tablet stamped "402 VIN"	402.228

GRAYVILLE NORTH ALONG ILLINOIS CENTRAL RAILROAD AND PUBLIC ROADS VIA BROWN'S GAP TO BONE GAP.

	Feet.
Bone Gap, T. 1 S., R. 14 W., northwest corner of Miss M. D. Rice's millinery store, north side, in brick foundation, bronze tablet stamped "459 VIN"	459.271

BONE GAP ALONG PUBLIC ROADS VIA GARD'S POINT AND FRIENDSVILLE TO PATTON, THENCE SOUTH ALONG BIG FOUR R. R. TO MT. CARMEL.

Gard's Point, T. 1 S., R. 13 W., Lick Prairie Church, northeast corner, at east side of, iron post stamped "434 VIN"	433.9
Patton, T. 1 N., R. 12 W., frame building of J. W. Elliott; at southeast corner and 1 foot southwest of corner, 8 inches above ground, iron post stamped "416 VIN"	416.646

CLAREMONT QUADRANGLE—AT FRIENDSVILLE.

Friendsville, T. 1 N., R. 13 W., at southeast corner of Dr. C. S. Couch's house, 3 feet above ground, in east face of wall, bronze tablet stamped "482 VIN"	482.306

Primary Leveling.

MADISON AND ST. CLAIR COUNTIES—EAST ST. LOUIS QUADRANGLE.

The elevations in the following list depend on the U. S. Coast and Geodetic Survey bench mark I3, being a mark on a large bronze plate with the inscription "U. S. Coast and Geodetic Survey Bench Mark 1882," in the south face of the eastern land pier of the Great Bridge at East St. Louis, its accepted elevation being 413.966 feet above mean sea level as determined by latest adjustment.

The leveling was done under the direction of Mr. Chas. E. Cooke, topographer, by Mr. L. Scott Smith, levelman.

The bench marks are stamped "ST. LOUIS" in addition to figures of elevation.

EAST ST. LOUIS GREAT BRIDGE ALONG HIGHWAY TO EDGEMONT, THENCE NORTH TO MOLIENBOCK, THENCE WEST TO GRANITE CITY.

	Feet.
East St. Louis, a mark on large bronze coast survey plate on east land pier of "Great Bridge," U. S. C. S. B. M. I_3	413.966
Caseyville, 0.25 mile east of, north end and west abutment railroad bridge, aluminum tablet stamped "449 St. Louis"	449.160
Bolienblock Horseshoe Lake, northeast end of bayou, southeast abutment iron bridge over, aluminum tablet stamped "415 St Louis"	414.795
Granite City, northwest face, northeast wing public school house, top of stone foundation, aluminum tablet stamped "431 St. Louis"	430.978
Granite City, signal tower opposite union station, southwest corner of foundation (standard city B. M.) top stone of	425.888

EDGEMONT SOUTH ALONG HIGHWAY TO OGLESBY, THENCE TO SCHNAFF HOUSE. (SINGLE SPUR LINE.)

Ogles, 100 yards north of, west bound track of Illinois Central Railroad, on east side of road, south foundation of large brick house, aluminum tablet stamped "576, St. Louis"	576.129
T. 1 N., R. 9 W., Sec. 17, 0.25 mile west of center of, 1.2 mile northeast of Imbs, John Schnaff's house, in northwest corner foundation, aluminum tablet stamped "517, St. Louis"	517.085

Primary Control.

METHODS.

In order that the separate atlas sheets of the topographic map of Illinois may match exactly in position as they are extended from one end of the State to the other, it is essential that that they be based on exact geodetic positions showing latitude and longitude of important points throughout the area under survey, and azimuth or relation to true north and south of important lines. This work is started from careful base lines measured by the Coast Survey and the survey of the Great Lakes, which was executed some years ago. The coöperative survey starting from these extends by primary triangulation in some cases, and by lines of very careful primary traverse measured with compensated steel tape and large transits about the edges of each quadrangle under survey. The effect is to secure geodetic positions along the borders of these quadrangles on which to base all the adjustment of public land lines and all roads within the area of each, and assure the matching of the edges of adjacent sheets. The positions thus procured are permanently marked with metal posts or tablets, and will be of great utility hereafter as property becomes more valuable, in fixing definitely and permanently property lines and political boundaries. The instructions under which this class of work is executed are appended hereto, as is a list of positions so determined both prior to and since coöperation.

Secondary locations.—Traverse surveys for horizontal control were run during the field season of 1905 over every road and path in the area upon which topographic mapping was in progress. There were run 6,223 miles of such traverse surveys, every bend and every house along the roads being accurately located. In 1906 there were run 3,227 miles of similar road traverse.

RESULTS OF PRIMARY HORIZONTAL CONTROL—1896 TO 1906*.

The necessary primary control upon which to base topographic mapping has been obtained by running careful transit lines between triangulation stations previously established by other Federal Bureaus, namely the Coast and Geodetic Survey, the U. S. Lake Survey and the engineer corps of the U. S. Army. These transit, or primary traverse lines are run by a party consisting of five men, the chief of party acting as observer, one recorder, two chainmen, and a rodman. The instrumental equipment consists of one good transit reading by vernier to 20″ to 30″; one 300-foot steel tape, one 100-foot steel tape, four hand recorders, two thermometers, two flag poles, and a good watch.

Each deflection angle is measured at least twice and if the measures differ more than 60″ additional measurements are obtained which do not differ by that amount.

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* The work of 1896 to 1904 was prior to coöperation, and that of 1905 and 1906 was in coöperation with the State.

Distances are usually obtained with the 300-foot tape, but when short sights only can be had, the 100-foot tape is used.

The true direction or azimuth of the line is obtained by observations on Polaris at stations not more than ten miles apart. It is customary to observe for azimuth on every clear night during the progress of the work. The tape when used is kept under a certain standard tension by means of a spring balance, and the temperature is taken at frequent intervals so that a correction can be applied when the measurements are made during extremely hot or cold weather. The line as run thus furnishes the necessary data from which as many geographic positions can be computed as desired. Usually such positions as roads crossings, railroad stations, etc., are computed at intervals of one mile, and the positions of the permanent station marks every eight miles.

Geographic Positions Established by the U. S. Geological Survey Prior to Coöperation.

Primary Railroad Traverse.

The following geographic positions were determined in 1896 from primary railroad traverse by Mr. George T. Hawkins, starting at Seehorn triangulation station of the Mississippi River Commission, and running along the Wabash Railroad to Springfield, connecting with United States Coast and Geodetic Survey astronomic pier in Capitol grounds; then from junction of Wabash with Chicago, Peoria & St. Louis Railroad at Jacksonville, along the latter road to Springfield via Havana, and from Havana to a point about ten miles northwest of Havana along the C., B. & Q. R. R.

HULL QUADRANGLE—PIKE COUNTY.

Position.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Seehorn triangulation station	39 45 38.9	91 15 55.1
Junction of railroads at Hull	39 42 20.8	91 12 26.2
Kinderhook depot	39 42 05.5	91 09 16.3
Barry depot	39 42 01.4	91 02 27.4
Corner secs. 19, 30, 25, 24, T. 4 S., Rs. 5, 6 W	39 41 54.5	91 01 46.9

BAYLIS QUADRANGLE—PIKE COUNTY.

Position.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Arden depot	39 43 17.5	90 56 36.9
Corner secs. 7, 18, 13, 12, T. 4 S., Rs. 4, 5 W	39 43 39.9	90 54 56.2
Baylis depot	39 43 41.8	90 54 30.4
New Salem depot	39 42 02.8	90 50 42.7
¼ corner secs. 19, 24, T. 4 S., R., 3, 4 W	39 42 01.6	90 47 59.1
Pittsfield Junction	39 42 01.7	90 47 45.0

NAPLES QUADRANGLE—PIKE AND SCOTT COUNTIES.

Position.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Griggsville depot	39 42 03.1	90 43 55.4
¼ corner secs. 23, 24, T. 4 S., R. 3 W.	39 42 02.6	90 42 13.0
Valley City depot	39 42 22.0	90 39 07.9
Middle drawbridge at Valley City	39 42 23.6	90 38 44.1
Naples depot	39 45 09.6	90 36 26.2
Corner secs 7, 18, 13, 12, T. 15 N., Rs. 13, 14 W.	39 45 15.0	90 35 45.8
Bluffs depot	39 44 59.8	90 32 10.6

CHAPIN QUADRANGLE—MORGAN AND SCOTT COUNTIES.

Position.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Neeleys depot	39 45 20.5	90 28 34.8
Morganton	39 45 53.8	90 25 52.2
Chapin railroad junction	39 45 54.4	90 24 03.4
Center sec. 16, T. 15 N., R. 11 W.	39 44 44.0	90 19 39.2
Markham depot	39 44 44.0	90 19 38.8
¼ corner secs. 13, 18, T. 15 N., Rs. 10, 11 W.	39 44 42.4	90 15 41.5

JACKSONVILLE QUADRANGLE—MORGAN COUNTY.

Position.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Jacksonville, junction Wabash and Chicago, Peoria and St. Louis railroads	39 44 11.9	90 13 11.0
Section corner 2 miles east of Jacksonville and 600 feet north of railroad	39 44 06.5	90 11 46.1
Arnold depot	39 43 19.0	90 08 40.3
Orleans depot	39 43 25.9	90 04 45.7
Alexandria depot	39 43 26.4	90 02 21.0

NEW BERLIN QUADRANGLE—MORGAN AND SANGAMON COUNTIES.

Position.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Browns Crossing depot	39 43 27.0	89 59 04.4
Island Grove depot	39 43 27.2	89 57 39.3
Corner secs. 19, 30, 25, 24, T. 15 N., Rs. 7, 8 W.	39 43 33.2	89 55 38.9
Berlin depot	38 43 27.6	89 54 42.6
Bates depot	39 43 28.1	89 50 54.9
Curran depot	39 44 30.2	89 46 17.5
¼ corner secs. 16, 21, T. 15 N., R. 6 W.	39 44 31.8	89 46 17.1
Junction of Wabash and Chicago, Peoria and St. Louis railroads.	39 44 38.1	89 45 43.9

SPRINGFIELD QUADRANGLE—SANGAMON COUNTY.

Position.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Sanger depot	39 45 13.8	89 43 11.4
¼ corner secs. 7, 8, T. 15 N., R. 5 W.	39 45 53.1	89 41 10.8
Junction of Wabash and Chicago and Alton railroads	39 46 19.0	89 39 09.0
Springfield pier (United States Coast and Geodetic Survey)	39 47 56.8	89 39 19.4

VIRGINIA QUADRANGLE—CASS AND MORGAN COUNTIES.

Position.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Corner secs. 3, 4, Ts. 15, 16 N., R. 10 W.	39 47 09.2	90 12 38.2
Leiterberry depot	39 51 08.1	90 11 58.8
Corner secs. 2, 3, Ts. 16, 17 N., R. 10 W.	39 52 23.6	90 12 06.8
Little Indian depot	39 53 14.3	90 12 06.6
Corner secs. 14, 15, 22, 23, T. 17 N., R. 10 W	39 55 00.3	90 12 05.9
Railway junction, Virginia	39 56 58.5	90 12 05.1
¼ corner secs. 2, 35, Ts. 17, 18 N., R. 10 W	39 57 37.8	90 11 31.2
Anderson depot	39 58 54.7	90 09 35.7

SAIDORA QUADRANGLE—CASS AND MORGAN COUNTIES.

Position.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Chandlerville depot	40 02 59.7	90 09 08.6
Corner secs. 29, 30, 31, 32, Ts. 18, 19 N., R. 9 W	40 03 51.1	90 08 43.7
Corner secs. 7, 8, 17, 18, at Saidora	40 06 16.5	90 08 44.3
Saidora depot	40 06 17.8	90 08 44.3
Corner secs. 5, 6, 31, 32, Ts. 19, 20 N., R. 9 W	40 08 00.6	90 08 44.7
Bath depot	40 11 28.4	90 08 19.0
¼ corner secs. 27, 34, T. 21 N., R. 9 W	40 13 50.7	90 06 20.8
Corner secs. 7, 18, 13, 12, T. 21 N., Rs. 8. 9 W	40 16 28.9	90 03 24.0
¼ corner secs. 17, 20, T. 20 N., R. 8 W	40 10 37.6	90 01 27.4
Kilbourne depot	40 09 08.3	90 00 43.7

ATTERBURG QUADRANGLE—MASON AND MENARD COUNTIES.

Position.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Oakford depot	40 06 09.2	89 57 55.1
Atterberry depot	40 03 36.4	89 55 29.9
Corner secs. 29, 30, 31, 32, T. 19 N., R. 7 W	40 03 41.3	89 55 21.7
Corner at Hilltop, 340 feet north of railroad	40 01 32.1	89 52 29.7
Petersburg depot	40 00 41.2	89 50 46.4

TALLULA QUADRANGLE—MENARD COUNTY.

Position.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Corner secs. 19, 30, 25, 24, T. 18 N., Rs. 6, 7 W	39 59 21.8	89 49 38.8
Tice depot	39 59 07.7	89 47 42.8
¼ corner secs. 26, 27, T. 18 N., R. 6 W.	39 58 57.9	89 45 07.7

SPRINGFIELD QUADRANGLE—SANGAMON COUNTY.

Position.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Athens depot	39 57 53.1	89 43 27.9
Cantrell depot	39 56 14.8	89 40 32.4

SPRINGFIELD QUADRANGLE—SANGAMON COUNTY.

Position.	Latitude.			Longitude.		
	°	′	″	°	′	″
Corner (?) secs. 15, 16, 21, 22, T. 17 N., R. 5 W	39	55	56.6	89	39	54.6
¼ corner secs. 27, 28, 1 mile north of Cora	39	54	38.6	89	38	42.6
Cora depot	39	53	45.7	89	38	07.0
Junction of Chicago and Alton with Chicago, Peoria and St. Louis railroads	39	49	51.5	89	38	03.8
Junction of Chicago and Alton with Baltimore and Ohio railroads.	39	48	16.8	89	39	05.6

HAVANA QUADRANGLE—MASON COUNTY.

Position.	Latitude.			Longitude.		
	°	′	″	°	′	″
Havana depot	40	17	37.2	90	03	56.0
West Havana depot	40	17	55.3	90	04	15.7
Center sec. 11, T. 4 N., R. 3 E.	40	19	39.3	90	06	54.6
Corner secs. 1, 2, 11, 12, T. 4 N., R. 3 E.	40	20	58.8	90	07	28.5
SW. corner NE. ¼ of NE. ¼ sec. 3, T. 4 N., R. 3 E.	40	21	37.5	90	08	53.5

The following geographic positions were determined in 1897 by Mr. George T. Hawkins by primary traverse betwen Lake Survey triangulation station Fairmount and the Indiana-Illinois State line. Traverse follows the Wabash Railroad.

DANVILLE QUADRANGLE—VERMILION COUNTY.

Position.	Latitude.			Longitude.		
	°	′	″	°	′	″
Fairmount triangulation station	40	01	35.8	87	50	48.8
Fairmount depot	40	02	48.6	87	49	54.2
Junction. Wabash and Chicago Eastern Illinois railroads	40	02	57.2	87	48	22.4
Catlin depot	40	03	45.3	87	42	13.9
Permanent bench mark at Catlin	40	03	53.8	87	42	02.8
One-fourth corner sections 24 and 25, T. 19 N., R. 12 W	40	05	12.8	87	40	03.4
Crossing at Tilton	40	05	54.4	87	38	53.4
Junction, Wabash and Chicago Eastern Illinois railroads	40	06	04.4	87	38	37.8
Danville, Wabash depot	40	07	30.7	87	37	31.2
Junction Wabash and "Big 4" railroads	40	08	09.0	87	37	05.0
Corner sections 26, 27, 34 and 35, T. 20 N., R. 11 W.	40	09	40.3	87	35	01.1
Crossing of Wabash Railroads and Indiana-Illinois State line	40	11	51.6	87	31	51.0

The following geographic positions were determined by primary traverse by Mr. George T. Hawkins, topographer, in August, 1901.

The line starts from an adjusted position established in 1899 near Evansville, and follows the Evansville and Terre Haute Railroad to Vincennes, where it was tied to the Coast and Geodetic Survey astronomic pier. From a point on this line at Princeton, Ind., a line was run along the Air Line Railroad to Mt. Carmel, Ill., thence by Louisville & Nashville Railroad to Evansville, Ind., and tied to original point.

MOUNT CARMEL QUADRANGLE—EDWARDS AND WABASH COUNTIES.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Mount Carmel station, Air Line Railroad	38	24	16.2	87	45	25.7
Air Line and "Big 4" Railway Junction, point 300 feet southwest of, on "Big 4" Railway	38	24	34.2	87	46	27.8
T. 1 S., R. 12 W., center section 30	38	24	06.2	87	47	13.9
Schrodt's, road crossing at	38	22	59.6	87	49	21.3
Keen station	38	21	08.8	87	52	02.6
T. 2 S., R. 13 W., one-fourth corner between sections 18 and 19	38	20	04.8	87	54	00.0
Cowling station	38	18	41.2	87	56	13.1
Grayville station, "Big 4" Railway	38	15	36.9	87	59	29.4
Grayville, crossing at ferry	38	15	27.7	87	59	27.7

CARMI QUADRANGLE—EDWARDS AND WABASH COUNTIES.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Calvin, one-fourth mile northeast of, corner on township line	38	12	59.6	88	00	38.8
Calvin station	38	12	36.0	88	01	01.7
T. 4 S., Rs. 10 and 11 W., corner sections 7, 12, 13 and 18	38	11	02.3	88	02	23.5
Crossville station	38	09	50.2	88	03	49.4
Road crossing, north and south	38	08	05.2	88	05	43.7
Carmi, junction of "Big 4" and Louisville and Nashville railroads	38	05	47.4	88	09	20.4

GEOGRAPHIC POSITIONS ALONG LOUISVILLE AND NASHVILLE RAILROAD FROM CARMI, ILL., TO MAUMEE, IND.

Position.	Latitude.			Longitude.		
ILLINOIS.	°	′	″	°	′	″
Epworth, road crossing at	38	04	17.7	88	06	20.2
T. 5 S., R. 10 W., corner sections 21, 22, 27 and 28	38	04	05.9	88	05	46.9
Maumee, road crossing at	38	02	10.5	88	02	45.9

PEORIA QUADRANGLE—PEORIA AND TAZEWELL COUNTIES.

The following geographic positions were determined by primary traverse run in 1902 by Mr. J. R. Ellis. Starting from adjusted position of the Chicago, Peoria & St. Louis Railway station at Havana, the line follows that railway to a point about 3.5 miles northeast of Parkland, thence north to Morton, thence north on Vandalia Railway to Farmdale, thence north and west through Peoria, thence west and south by wagon roads to Reed City, thence east by Toledo, Peoria & Western Railway to Pekin, thence southwest to point where line first left railway over Chicago, Peoria & St. Louis Railway.

GEOGRAPHIC POSITIONS ALONG THE CHICAGO, PEORIA & ST. LOUIS RAILWAY.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Havana station	40	17	37.2	90	03	56.0
Road crossing north and south (private)	40	29	51.3	89	43	07.1

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 24 N., R. 5 W., corner sections 29, 30, 31 and 32	40	29	37.0	89	42	07.7
T. 24 N., R. 5 W., corner sections 28, 29, 31 and 32	40	29	38.7	89	48	58.3
T. 24 N., R. 5 W., corner sections 26, 27, 34 and 35	40	29	39.9	89	38	41.2
T. 24 N., R. 5 W., corner sections 25, 26, 35 and 36	40	29	40.4	89	37	32.7
Ts. 23 and 24 N., Rs. 4 and 5 W., corner of	40	28	49.2	89	36	22.5
T. 24 N., R. 4 W., corner sections 28, 29, 32 and 33	40	29	41.8	89	34	05.5
T. 24 N., R. 4 W., corner sections 27, 28, 33 and 34	40	29	42.2	89	32	58.2
T. 24 N., R. 4 W., corner sections 26, 27, 34 and 35	40	29	42.9	89	31	49.9
T. 24 N., R. 4 W., corner sections 25, 26, 35 and 36	40	29	43.4	89	30	42.3
T. 24 N., R. 3 and 4 W., corner sections 25, 30, 31 and 36	40	29	43.9	89	29	34.4
T. 24 N., R. 4 W., $\frac{1}{4}$ corner between sections 25 and 30	40	30	10.6	89	29	34.7
Road, corner in	40	30	11.5	89	28	18.6
Road east and west	40	31	30.0	89	28	20.1
T. 24 N., R. 4 W., corner sections 7, 8, 17 and 18	40	32	22.1	89	28	37.7
T. 24 N., R. 4 W., corner sections 5, 6, 7 and 8	40	33	14.4	89	28	38.9
Ts. 24 and 25 N., R. 4 W. corner sections 5, 6, 31 and 32	40	34	06.6	89	28	42.2
Maple Grove school house, road corner at	40	35	25.3	89	28	30.6

GEOGRAPHIC POSITIONS ALONG THE VANDALIA RAILWAY.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Morton crossing of Tremont and St. Louis Railway	40	36	30.7	89	27	48.1
Road crossing east and west	40	37	25.5	89	29	00.2
Road crossing east and west	40	39	35.8	89	30	06.3
Road crossing north and south	40	40	16.1	89	31	21.5

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Three roads, junction of	40	40	57.7	89	33	13.4
Creek northwest, bridge over	40	41	41.8	89	32	26.7
Creek west, bridge over	40	42	49.0	89	31	46.6
Crossroads	40	43	30.7	89	31	24.5
T. 26 N., R. 4 W., corner sections 1, 2, 11 and 12	40	43	56.8	89	31	18.8
Pitt and mound 45 feet south of road on top of hill	40	43	58.2	89	30	30.8
Illinois river, center draw to wagon bridge, over	40	43	27.9	89	32	52.9
Peoria, North Perry street and Abingdon avenue, corner of	40	42	35.3	89	34	17.6
Peoria, Knoxville and Frye avenues, corner of	40	42	44.4	89	35	38.8
Peoria, Elizabeth and Nebraska avenues, corner of	40	42	37.9	89	36	13.5
Peoria, Main and Franklin streets, corner of	40	41	59.4	89	36	33.6
Road west	40	42	17.0	89	38	08.9
Pottstown, railway crossing at	40	43	05.3	89	39	39.5
T. 9 N., R. 7 E., $\frac{1}{4}$ corner between sections 27 and 34	40	43	32.1	89	41	23.3
T. 9 N., R. 11 E., corner sections 27, 28, 33 and 34	40	43	32.2	89	41	57.6
T. road north	40	43	32.3	89	43	06.7
T. road east	40	43	06.1	89	44	50.1
Ts. 8 and 9 N., R. 7 E., $\frac{1}{4}$ corner between sections 6 and 31	40	42	39.9	89	44	50.6
Hale, crossing Iowa Central Railway at	40	41	29.3	89	44	49.6
T. 8 N., Rs. 6 and 7 E., corner 7, 12, 13 and 18	40	40	55.1	89	45	25.2
Gravel road east and west	40	39	38.3	89	46	07.6
Ts. 7 and 8 N., Rs. 6 and 7 E., corner 7, 12, 13 and 18	40	37	27.0	89	45	24.4
T. road east	40	36	20.8	89	45	23.6
T. road east	40	35	16.0	89	45	22.9

GEOGRAPHIC POSITIONS ALONG THE TOLEDO, PEORIA & WESTERN RAILWAY.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Reed City, railway crossing at	40	34	32.5	89	45	03.2
Road crossiog north and south	40	33	59.0	89	43	50.2
Road crossing north, east, south and west	40	34	21.2	89	42	31.5
Road crossing east and west	40	34	48.5	89	41	30.0
Orchard Mines, road crossing at	40	35	20.1	89	40	41.5
Pekin, center of draw in wagon bridge	40	34	22.3	89	39	18.2

GEOGRAPHIC POSITIONS ALONG THE CHICAGO, PEORIA & ST. LOUIS RAILWAY.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Chicago, Peoria & St. Louis Railway and Peoria & Pekin Union Railway, crossing of	40	33	38.8	89	39	21.8
Globe Distillery, east and west road crossing at	40	33	03.5	89	39	55.9
Road crossing east and west	40	32	16.1	89	40	44.7
T. 24 N., R. 5 W., ¼ corner between sections 17 and 20	40	31	22.8	89	41	35.0

Primary Traverse.

GALLATIN AND WHITE COUNTIES—NEWHAVEN QUADRANGLE.

The following geographic positions were located by primary traverse in 1903 by Mr. J. R. Ellis. The line starts from an adjusted traverse position at Mannie and follows highways, south to border of quadrangle; thence west to northwest corner of quadrangle; thence south along west border of quadrangle to Ridgeway; thence east to Uniontown, Ky., connecting at the latter place with spur line from Henderson, Ky.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Mannie, road crossing at	38	02	10.5	88	02	45.9
T. 6 S., Rs. 10 and 11 E., corner sections 1, 6, 7 and 12	38	01	29.2	88	02	29.8
T. 6 S., Rs. 10 and 11 E., quarter corner between sections 13 and 18	37	00	02.6	88	02	30 3
T. 7 S., R. 10 E., quarter corner between sections 23 and 26	37	58	52.3	88	04	10.3
T. 6 S., R. 10 E., corner sections 22, 23, 26 and 27	37	58	52.9	88	04	42.7
T. 6 S., R. 10 E., corner sections 21, 22, 27 and 28	37	58	53.4	88	05	49.7
Emma, crossroads at church in north part of	37	58	53.7	88	07	11.7
Emma, T road south at	37	58	40.7	88	07	08.5
Emma, crossroads 0.75 mile south of	37	58	01.4	88	07	13.3
T. 6 S., R. 10 E., corner sections 29, 30, 31 and 32	37	58	02.0	88	08	03.0
T. 6 S., Rs. 9 and 10 E., corner sections 25, 30, 31 and 36	37	58	02.7	88	09	08.6
R. 6 S., R. 9 E., corner sections 25, 26, 35 and 36	37	58	02.8	88	10	14 8
T. 6 S., R. 9 E., corner sections 26, 27, 34 and 35	37	58	03.2	88	11	21.5
T. road north	37	58	03.8	88	14	08.2
Range line road at T road east	37	57	51.0	88	15	09.8
Road at T road east	37	57	51.0	88	15	48.3
Ts. 6 and 7 S., Rs. 8 and 9 E., corner sections 31, 36, 1 and 6	37	57	11.2	88	15	48.2
T. 7 S., Rs. 8 and 9 E., corner sections 7, 12, 13 and 18	37	55	27.1	88	15	43.9
T. 7 S., Rs. 8 and 9 E., corner sections 13, 18, 19 and 24	37	54	36.0	88	15	43.9
T. 7 R , Rs. 8 and 9 E., corner sections 19, 24, 25 and 30	37	53	43.6	88	15	43.1
T. 7 S., Rs. 8 and 9 E., corner sections 25. 30, 31 and 36	37	52	50.1	88	15	44.3
T road west	37	52	23.6	88	15	53.2
T road west	37	51	30.0	88	15	02.5
T road east	37	50	38.4	88	14	45.7
T road east	37	49	47.8	88	14	48.0
T road east	37	48	54.8	88	14	46.6
Ridgeway, crossroads 0.5 mile east of	37	48	02.2	88	14	46.9
T. 8 S., R. 9 E., corner sections 29, 30, 31 and 32	37	47	35.8	88	14	47.1
T. 8 S., R. 9 E., corner sections 28, 29, 32 and 33	37	47	34.5	88	13	40.5

GEOGRAPHIC POSITIONS ALONG HIGHWAYS—*Continued.*

Station.	Latitude.	Longitude.
T. 8 S., R. 9 E., corner sections 27, 28, 33 and 34	37 47 32.9	88 12 33.5
T. 8 S., R. 9 E., corner sections 26, 27, 34 and 35	37 47 33.4	88 11 29.9
T. 8 S., R. 9 E., corner sections 25, 26, 35 and 36	37 47 33.7	28 10 24.2
T road south	37 47 33.6	88 09 16.4
T. 8 S., R. 10 E., quarter corner between sections 30 and 31	37 47 33.0	88 08 45.3
Intersection of northwest and southeast road and road east to Sandy Ford	37 47 24.1	88 08 07.7
Intersection of roads at mouth of lane just east of sawmill	37 47 03.2	88 08 14.8
Schoolhouse, T road east about 2,000 feet south of	37 48 07.5	88 06 49.4
Schoolhouse, T road south at house about 3,000 north of	37 48 47.4	88 05 19.2

GALLATIN, HAMILTON, SALINE AND WHITE COUNTIES—ELDORADO QUADRANGLE.

The line starts from adjusted traverse position at Ridgeway and follows Baltimore & Ohio Southwestern Railroad south to point about one mile northwest of Cypress Junction, thence along Louisville & Nashville Railroad through Equality, Eldorado, and Broughton to point 0.5 mile south of Dale, thence along north border of quadrangle by public highways, connecting with adjusted traverse position about five miles east of Norris City.

GEOGRAPHIC POSITIONS ALONG THE BALTIMORE AND OHIO SOUTHWESTERN RAILROAD.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
Ridgeway, street crossing Baltimore & Ohio Southwestern Railroad at station	37 47 59.0	88 15 36.9
Road crossing east and west	37 46 19.5	88 15 17.7
Bartley, east and west road crossing	37 45 17.3	88 15 09.5

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Station.	Latitude.	Longitude.
	° ′ ″	° ′ ″
T road north	37 43 58.8	88 14 59.0
T. 9 S., R. 9 E., corner sections 17, 18, 19 and 20	37 43 58.9	88 14 48.2

GEOGRAPHIC POSITIONS ALONG THE LOUISVILLE AND NASHVILLE RAILROAD

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Road crossing north and south	37	43	46.1	88	17	03.8
Road crossing north and south	37	43	49.9	88	18	10.5
Equality, road crossing north and south just west of water tank	37	44	00.6	88	20	23.2
Equality, road crossing north and south 180 feet west of station	37	43	58.4	88	20	57.8
T. 9 S., R. 7 E., quarter corner between sections 12 and 13	37	44	53.3	88	22	53.8
Road crossing east and west	37	46	11.6	88	24	04.4
Road crossing north and south	37	47	25.5	88	25	06.2
Road crossing north and south	37	47	59.0	88	25	42.5
Eldorado, crossing Louisville & Nashville and Big Four railroads	37	48	53.8	88	26	00.1
Road crossing east and west	37	50	09.3	88	26	24.3
T. 8 S., R. 7 E., quarter corner between sections 9 and 16	37	50	09.2	88	26	14.3
Road crossing east and west	37	51	14.9	88	26	33.1
Road crossing east and west	37	52	19.7	88	26	41.8
Francis Mills, road crossing	37	53	38.5	88	26	52.2
Road crossing east and west	37	54	30.9	88	26	59.2
T. 8 S., R. 7 E., corner sections 16, 17, 20 and 21	37	54	30.9	88	27	06.5
Road crossing east and west	37	55	12.0	88	27	06.4
Broughton, road crossing 500 feet north of station	37	56	15.9	88	27	35.5
Road crossing east and west near spur head block	37	57	41.9	88	28	23.3
Road crossing east and west	37	58	27.4	88	28	48.6
Dale, road crossing 0.5 mile south of	37	59	06.7	88	29	10.5

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T road north	37	59	06.4	88	22	03.7
T road south at quarter corner	37	58	53.7	88	57	21.7
Road south	37	58	54.0	88	25	30.6
T. 6 S., R. 7 E., corner secs. 22, 23, 26, and 27	37	58	54.4	88	24	36.1
T. 6 S., R. 7 E., corner secs. 23, 24, 25, and 26	37	58	54.7	88	23	30.0
T. 6 S., Rs. 7 and 8 E., corner secs. 19, 24, 25 and 30	37	58	56.5	88	22	24.2
T. 6 S., R. 8 E., corner secs. 19, 20, 29, and 30	37	58	56.2	88	21	18.1
T. 6 S., R. 8 E., corner secs. 20, 21, 28, and 29	37	58	56.1	88	20	12.3
T. 6 S., R. 8 E., corner secs. 21, 22, 27, and 28	37	58	56.0	88	19	06.1
T. 6 S., R. 8 E., corner secs. 22, 23, 26, and 27	37	58	56.2	88	18	00.0
T. 6 S., R. 8 E., corner secs. 23, 24, 25, and 26	37	58	56.5	88	16	54.2
T. 6 S., Rs. 8 and 9 E., corner secs. 19, 24, 25, and 30	37	58	56.3	88	15	48.5

Geographic Positions Established in 1905-1906.

MADISON AND ST. CLAIR COUNTIES—BELLEVILLE QUADRANGLE.

The following geographic positions on the United States standard datum were determined by primary traverse in 1905 by Mr. J. R. Ellis, assistant topographer. The line starts from United States Coast and Geodetic Survey triangulation station, Sugarloaf, follows highways south to Belleville; thence east along the Southern Railway to east edge of quadrangle; thence along highways north to northeast corner of quadrangle, connecting with Berger triangulation station and Parkinson triangulation station; thence west along highways to northwest corner of quadrangle, and south to Sugarloaf triangulation station.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Station.	Latitude.	Longitude.
Sugarloaf triangulation station: Near middle of north line of NE. ¼, sec. 20, T. 3 N., R. 8 W., on bluff overlooking American Bottom, 3 miles northwest of Collinsville on land of C. Witte, on top of prominent mound, which is 50 feet above the ground to the east and 150 to 200 feet above American Bottom on west. Station mark: A marble post 6 by 6 inches by 2½ feet long, top		
1 inch above ground and marked thus: U. S. / C. & G. S.	° ′ ″ 38 42 05.3	° ′ ″ 90 00 27.5
Center of iron bridge near road corner	38 41 17.5	90 00 28.0
Collinsville crossing of Combs avenue and Clay street	38 40 05.9	89 59 41.0
Collinsville and Belleville road crossing Pennsylvania Railroad at electric power house	38 39 39.5	89 58 56.4
Collinsville, 3 miles southeast of; in southwest corner of stone foundation of Bethel Church, aluminum tablet stamped "Prim. Trav. Sta. No. 14, 1905."	° ′ ″ 38 38 41.1	° ′ ″ 89 57 42.1
T. 2 N., R. 8 W., secs. 10, 11, 14, and 15, road crossing near corner	38 37 17.9	89 57 58.3
T. 2 N., 8 W., quarter corner between secs. 22 and 23, T road east	38 36 20.8	89 57 58.2
Ridge Prairie saloon, crossroads at	38 35 33.4	89 57 58.1
Hy Pfeifer's saloon and hotel, 1 mile south of road west	38 34 23.8	89 57 57.7
T. road west at schoolhouse	38 33 35.9	89 57 56.2
Road crossing, O'Fallon branch Louisville and Nashville Railroad, 100 feet north of milepost 18	38 32 26.6	89 57 52.0
Belleville, street crossing Louisville and Nashville Railroad, main line	38 31 48.6	89 59 00.9
Belleville, in northeast corner of court-house yard, iron post stamped "Prim. Trav. Sta. No. 15, 1905"	38 30 47.3	89 58 50.3

GEOGRAPHIC POSITIONS ALONG SOUTHERN RAILWAY FROM BELLEVILLE EASTWARD.

Station.	Latitude.	Longitude.
Belleville, crossing of Southern Railway under Louisville and Nashville Railroad, near city reservoir	° ′ ″ 38 31 35.6	° ′ ″ 89 58 50.3
Mines, road crossing north and south	38 32 01.6	89 57 50.0
Road crossing north and south	38 32 00.9	89 56 49.3
T. 1 N., R. 8 W., quarter corner between secs. 13 and 14	38 32 01.4	89 56 49.3
Road crossing, north and south, 760 feet east of telegraph office	38 32 02.3	89 55 43.4
Shiloh station, milepost 22, road crossing north and south	38 32 02.8	89 53 55.7
Road crossing north and south between mileposts 23 and 24	38 32 00.7	89 52 07.6
Grassland on property of Chas. Griffin, northeast corner of post-office, bears S. 85° 40′ W., distant 110 feet, iron post stamped "Prim. Trav. Sta. No. 16, 1905"	38 31 57.1	89 50 19.1
Road crossing north and south, 150 feet west of milepost 27	38 31 58.1	89 48 25.0
Road crossing north and south, 170 feet west of milepost 28	38 31 57.1	89 47 18.7

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Station.	Latitude.	Longitude.
North and south road crossing of Southern Railway, near southwest corner of field of J. B. Freese, iron post stamped "Prim. Trav. Sta. No. 17, 1905"	° ′ ″ 38 31 55.6	° ′ ″ 89 45 38.9
T. 1 N., R. 6 W., near quarter corner between secs. 3 and 10, crossroads	38 33 13.8	89 45 06.6

GEOGRAPHIC POSITIONS ALONG HIGHWAYS—*Continued.*

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Truss Bridge	38	34	04.0	89	45	07.6
T. 2 N., R. 6 W., quarter corner between sections 27 and 34, crossroads	38	34	57.5	89	45	07.2
Summerfield, in water table at southeast corner of public school building, aluminum tablet stamped "Prim. Trav. Sta. No. 18, 1905"	38	35	56.3	89	45	09.8
Berger triangulation station, near northwest corner of NE. ¼ of NW. ¼ section 22, T. 2. N., R. 6 W., on property of Doctor Berger, 1 mile north of Summerfield and 3 miles east and ½ mile north of village of Lebanon. Station mark: An earthenware pyramid marked "U. S. C. S.," 36 inches below surface, above which is a marble post 30 inches long and 6 inches square, marked U. | S. C. & G. | S. its upper surface even with the ground. Western reference mark is a marble post 32 inches long, 4 inches square, in range with eastern row of trees in Doctor Berger's orchard; it is, as nearly as could be determined, on north boundary of section 22, which is boundary of Berger's land. Position of western reference mark	38	36	42.4	89	45	32.1
T. 2 N., R. 6 W., crossroads at 100 feet north to small bridge center	38	37	34.4	89	45	06.6
Crossroads 40 feet southwest to mail box, 36 feet northwest to culvert	38	38	13.8	89	45	09.1
Ts. 2 and 3 N., R. 6 W., quarter corner between sections 3 and 34, crossroads at; also line between Madison and St. Clair counties	38	39	18.8	89	45	11.4
T. 3 N., R. 6 W., quarter corner between sections 22 and 27, T road south	38	41	04.3	89	45	13.3
T road east, 160 feet south of iron bridge	38	41	57.5	89	45	47.8
St. Jacobs, crossroads at Nollbaner's hotel, in south part of	38	42	50.8	89	46	05.6
Crossroads at quarter corner between sections 11 and 14	38	42	49.5	89	44	08.4
Crossroads at quarter corner between sections 12 and 13	38	42	47.9	89	43	01.6
Parkinson triangulation station: On land of M. A. Parkinson, in middle of NE. ¼ section 12, T. 3 N., R. 6, W., and 1.5 miles west by south from Highland. Station mark: The vertex of a hollow square earthenware pyramid 3 feet below surface, with letters "U. S. C. S." cut on its sides, over which is a marble post 6 by 6 inches and 2.25 feet long, on top of which letters "U. S. C. & G. S." are cut. Reference marks: Two marble posts 5 inches square, 2.5 feet long, 2 inches above ground with a line diagonally across tops terminating in arrowhead, arrowhead pointing to station; northeast reference mark 18 feet 8¾ inches to station center; southeast mark 18 feet 8⅛ inches to station center; from center of northeast mark to southeast mark, 25 feet 8 inches; from station center to surveyors rock, 16 feet 9½ inches	38	43	26.9	89	42	44.3
Highland, about 2 miles west of; road crossing north and south, 480 feet east of water tank	38	44	02.9	89	42	48.3
In southwest corner of wood pasture owned by John Regel, iron post stamped "Prim. Trav. Sta. No. 19," corner stone in center of road bears S. 2° W., distant 17 feet	38	44	32.5	89	44	24.2
T road north, 16 feet northeast to cross on fence post, 19 feet northwest to west end of culvert	38	44	32.9	89	45	47.1
T road west at Marine cemetery	38	44	59.7	89	46	54.4
T road east 1.5 miles west of Marine cemetery	38	45	00.7	89	48	34.2
Silver Creek, national road over west fork of, center of iron bridge on	38	45	18.6	89	49	18.4
Troy, 5.2 miles northeast of; in northwest corner of pasture owned by Henry Wendler, at forks of road, iron post stamped "Prim. Trav. Sta. No. 20, 1905"	38	44	46.3	89	51	02.1
T. 4 N., R. 7 W., corner sections 27, 28, 33 and 34, T road south	38	45	32.3	89	52	27.7
T. 4 N., R. 7 W., corner sections 28, 29, 32 and 33, stone	38	45	32.1	89	53	35.1
T road west, 12 feet southeast to stone in north and south road	38	45	59.0	89	54	43.2

GEOGRAPHIC POSITIONS ALONG THE ILLINOIS CENTRAL RAILROAD BETWEEN MONT AND PETERS.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Mont, Illinois Central Railroad station	38	46	02.1	89	55	50.0
Suburban electric railroad crossing over Illinois Central Railroad	38	45	40.1	89	57	23.4
Glen Carbon, near Illinois Central Railroad station, on property of Madison Coal Co., southeast of Illinois Central Railroad station, iron post stamped "Prim. Trav. Sta. No. 21, 1905"	38	44	45.4	89	58	59.8
Peters station, road crossing north and south	38	44	30.9	90	00	07.3

CHAMPAIGN AND PIATT COUNTIES—MAHOMET QUADRANGLE.

The following geographic positions were obtained by primary traverse run by Mr. J. R. Ellis in 1905. The line starts from a position near Thomsonboro located by primary traverse, follows highways west, south, and east near borders of quadrangle, and is connected with an adjusted traverse position near Tolono. Positions are given on United States standard datum.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 21 N., R. 9 E., corner sections 29, 30, 31 and 32, at crossroads	40	14	19.3	88	12	45.5
T. 21 N., R. 9 E., northeast corner section 36, iron post stamped "Prim Trav. Sta. No. 8 1905"	40	14	18.5	88	13	54.8
T. 21 N., R. 9 E., corner sections 25, 26, 35 and 36, at crossroads	40	14	18.5	88	15	03.4
T. 21 N., R. 8 E., corner sections 26, 27, 34 and 35, T road east	40	14	18.0	88	16	12.2
T. 21 N., R. 8 E., quarter corner between sections 27 and 28, crossroads	40	14	44.2	88	17	21.2
T. 21 N., R. 8 E., quarter corner between sections 28 and 29, crossroads	40	14	43.8	88	18	29.5
T. 21 N., R. 8 E., quarter corner between sections 29 and 30, crossroads	40	14	43.5	88	19	39.0
T. 21 N., Rs. 7 and 8 E., quarter corner between sections 25 and 30, T. road east	40	14	43.7	88	20	47.2
T. 21 N., R. 7 E., quarter corner between sections 25 and 26, T road east	40	14	43.0	88	21	54.0
T. 21 N., R. 7. E., in northeast corner section 35, stone to corner sections 25, 26, 35 and 36 bears N. 41° 50′ E., distant 38 feet. Nail in blaze on east side of hickory tree bears S. 39° 20′ W., distant 29.4 feet. Iron post stamped "Prim. Trav. Sta. No. 9 1905"	40	14	16.4	88	21	54.2
T. 21 N., R. 7 E., quarter corner between sections 27 and 34, crossroads	40	14	16.9	88	23	36.6
T. 21 N., R. 7 E., corner sections 28, 29, 32 and 33, T road north	40	14	17.2	88	25	19.8
T. 21 N., R. 7 E., corner sections 29, 30, 31 and 32, T road north	40	14	17.4	88	26	28.6
T. 21 N., R. 7 E., corner sections 30, 31, west of T road east	40	14	17.4	88	27	36.9
T. 21 N., R. 6 E., corner sections 25, 26, 35 and 36, T road north	40	14	16.1	88	28	45.8
Mansfield, 1.5 miles north of; T. 21 N., R. 6 E., corner sections 26, 27, 34 and 35, 0.5 miles west of; in northwest corner of S. J. Trimmer's field at east and west road crossing, in limestone 30 by 10 by 8 inches, aluminum tablet stamped "Prim. Trav. Sta. No. 10"	40	14	15.9	88	30	08.7
Mansfield, crossing of Wabash Railway and Big Four Railway	40	12	51.1	88	30	39.6
Mansfield, T. road north at cemetery 1.5 miles south of	40	11	34.6	88	30	19.3
T. road west	40	10	16.0	88	30	02.3
T. 20 N., R. 6 E., corner sections 26, 27, 34 and 35, crossroads at	40	09	23.6	88	30	01.9
T. 20 N., R. 6 E., south corner sections 34, 35, T road north near	40	08	44.1	88	30	01.5
T. 19 N., R. 6 E., quarter corner between sections 2 and 3, crossroads near	40	08	04.5	88	30	04.6
Centerville, 1 mile south of; at T road west, in ground, in pasture owned by W. L. Alexander, 1.5 feet from north and south fence on east side of road, in stone 8 by 9 by 30 inches, aluminum tablet stamped "Prim. Trav. Sta. No. 11"	40	06	19.6	88	30	03.3
T. 19 N., R. 6 E., corner sections 22, 23, 14 and 15, T road east	40	05	53.6	88	30	03.3
T. 19 N., R. 6 E., corner sections 22, 23, 26 and 27	40	05	01.5	88	30	03.1
T. 19 N., R. 6 E., corner sections 26, 27, 34 and 35, T road west	40	04	08.8	88	30	03.3

GEOGRAPHIC POSITIONS ALONG HIGHWAYS—*Concluded.*

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 19 N., R. 6 E., south corner sections 34 and 35	40	03	16.8	88	30	02.9
T. 18 N., R. 6 E., corner sections 2, 3, 10 and 11, crossroads	40	02	24.1	88	30	02.4
T. 18 N., R. 6 E., corner sections 10, 11, 14 and 15, crossroads	40	01	31.4	88	30	01.9
T. 18 N., R. 6 E., corner sections 14, 15, 22 and 23	40	00	38.8	88	30	02.0
T. 18 N., R. 6 E., in northwest corner section 36, at crossroads, just inside of field and 3 feet from corner of hedge fence, iron post stamped "Prim. Trav. Sta. No. 12 1905"	39	59	45.8	88	30	01.2
T. 18 N., R. 6 E., corner sections 23, 24, 25 and 26, crossroads	39	59	46.6	88	28	53.1
T. 18 N., R. 6 E., east corner sections 24, 25, T road west	39	59	47.0	88	27	44.6
T. 18 N., R. 7 E., corner sections 19, 20, 29 and 30, crossroads	39	59	46.9	88	26	39.0
T. 18 N., R. 7 E., corner sections 20, 21, 27 and 28, crossroads	39	59	47.3	88	25	30.4
T. 18 N., R. 7 E., corner sections 21, 22, 27 and 28, crossroads	39	59	47.5	88	24	22.1
T. 18 N., R. 7 E., corner sections 22, 23, 26 and 27, crossroads	39	57	47.5	88	23	13.5
T. 18 N., R. 7 E., in southeast corner section 23, near southeast corner of L. W. Schrader's barn lot, at crossroads, 15 feet east to maple tree, iron post stamped "Prim. Trav. Sta. No. 13, 1905"	39	59	47.6	88	22	05.6
T. 18 N., R. 7 E., east corner of sections 24 and 25, crossroads, is 15 feet south of corner	39	59	47.8	88	20	56.6
T. 18 N., R. 8 E., corner sections 19, 20, 29 and 30, crossroads	39	59	47.2	88	19	53.4
T. 18 N., R. 8 E., corner sections 20, 21, 28 and 29, crossroads	39	59	46.8	88	18	45.8
T. 18 N., R. 7 E., corner sections 21, 22, 27 and 28, crossroads	39	59	46.1	88	17	37.7
T. 18 N., R. 7 E., corner sections 22, 23, 26 and 27, crossroads	39	59	45.2	88	16	29.7

LOGAN, MENARD AND SANGAMON COUNTIES—SPRINGFIELD QUADRANGLE.

The following geographic positions were obtained from primary traverse by Mr. E. L. McNair, topographer, in 1905. The line starts from adjusted position at Tice, follows wagon roads east, south, and west near border of quadrangle, and is connected with adjusted position at the crossing of the Wabash and Alton railways in South Springfield. Starting again from adjusted position at Athens the line follows wagon roads south along west border of quadrangle and is connected to adjusted position at Curran, at the crossing of the Wabash and the Chicago, Peoria & St. Louis railways. Positions are given on the Springfield astronomic datum.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Tice station	39	59	07.7	89	47	42.8
Tice, 3 corners 1.25 miles north of	40	00	15.7	89	47	41.6
T. 18 N., R. 6 W., quarter corner between sections 16 and 21	40	00	16.0	89	46	50.6
T. 18 N., R. 6 W., in northeast corner section 22, road south	40	00	02.8	89	45	45.4
T. 18 N., R. 6 W., in northeast corner section 23, iron post stamped "Prim. Trav. Sta. No. 1, 1905"	40	00	10.5	89	44	17.5
Indian Point Presbyterian Church, road south, 1,800 feet west of T. 18 N., R. 6 W., section 24, northwest corner of	40	00	11.4	89	43	46.4
T. 18 N., R. 5 W., quarter corner northeast quarter section 19 and southeast quarter section 18, T road west	40	00	16.2	89	41	56.6
T. 18 N., R. 5 W., corner sections 16, 17, 20 and 21, T road east	40	00	17.1	89	40	31.8
T. 18 N., R. 5 W., corner sections 15, 16, 21 and 22	40	00	17.1	89	39	23.9
T. 18 N., R. 5 W., corner sections 14, 15, 22 and 23, 4 corners	40	00	17.7	89	38	14.7
T. 18 N., R. 5 W., corner between sections 23 and 24	39	59	51.9	89	37	06.3
T. 18 N., Rs. 4 and 5 W., quarter corner between sections 19 and 24, Fancy Prairie station, crossing C. & A. Railway just south of	39	59	52.2	89	35	58.7
T. 18 N., R. 4 W., quarter corner between sections 19 and 20, T road west	39	59	53.0	89	34	43.8
T. 18 N., R. 4 W., corner sections 16, 17, 20 and 21	40	00	19.7	89	33	35.4
T. 18 N., R. 4 W., corner sections 15, 16, 21 and 22, T road south	40	00	20.2	89	32	27.0
T. 18 N., R. 4 W., corner sections 14, 15, 22 and 23	40	00	20.5	89	31	19.2
C. & A. Railway, crossing of	39	59	30.6	89	30	44.5

GEOGRAPHIC POSITIONS ALONG HIGHWAYS—*Concluded.*

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 18 N., R. 4 W., quarter corner between sections 26 and 35, 4 corners	39	58	36.6	80	30	43.6
T. 18 N., Rs. 3 and 4 W., corner sections 25, 36, 30 and 31, 4 corners	39	58	86.7	80	29	01.6
Williams, T. 18 N., Rs. 3 and 4 W., sections 25, 46, 30 and 31, in northeast corner of town of, 30 feet northeast of intersection of roads, iron post stamped "Prim. Trav. Sta. No. 2"	39	58	36.9	80	29	01.4
Ts. 17 and 18 N., Rs. 3 and 4 W., corner of, 4 corners	39	57	44.4	89	29	01.5
T. 17 N., Rs. 3 and 4 W., quarter corner between sections 12 and 7, T road north	39	56	26.0	89	29	00.6
T. 17 N., R. 4 W., quarter corner between sections 12 and 13, road west	39	55	59.4	89	29	34.6
T. 17 N., R. 4 W., quarter corner between sections 13 and 24, T road east	39	55	07.1	89	29	34.3
T. 17 N., R. 4 W., quarter corner between sections 24 and 25, T road east	39	54	15.2	89	29	33.8
T. 17 N., R. 6 W.. quarter corner between sections 25 and 36, 4 corners	39	53	22.8	89	29	33.3
Ts. 16 and 17 N., R. 4 W., quarter corner sections 1 and 36, 1.25 miles east of Barclay. 3.5 feet in ground, iron post stamped "Prim. Trav. Sta. No. 3, 1905"	39	52	30.1	89	29	32.7
Ts. 16 and 17 N., R. 4 W., quarter corner sections 2 and 35, 0.25 mile east of Barclay, 4 corners	39	52	29.4	89	30	41.2
T. 16 N., R. 4 W., quarter corner between sections 2 and 11, T road north	39	51	37.0	89	30	40.4
Interurban Electric Railway, T. 16 N., R. 4 W., on line of sections 11 and 14, crossing of	39	50	44.4	89	36	23.0
T. 16 N., R. 4 W., center section 23, T road north	39	49	27.6	89	30	42.0
T. 16 N., R. 4 W., near center of section 24, 4 corners	39	49	28.4	89	29	48.0
T. 16 N., R. 4 W., on line sections 25 and 26, T road north	39	48	11.9	89	29	13.7
T. 16 N., R. 4 W., corner sections 25, 26, 35 and 36, T road south	39	48	12.4	89	30	05.8
Ts. 15 and 16 N., quarter corner section 2	39	47	19.6	89	30	31.2
T. 15 N., R. 4 W., northeast quarter section 11, T road east	39	46	13.9	88	30	12.7
T. 15 N., R. 4 W., quarter corner sections 13 and 14, 1.9 miles east of Rochester: near T road north, iron post stamped "Prim. Trav. Sta. No. 4, 1905"	39	45	01.3	89	29	54.2
Rochester, T. 15 N., R. 4 W., southwest quarter of section 15, 4 corners	39	45	00.8	89	32	03.2
T. 15 N., R. 4 W., in northeast corner section 17, T road south	39	45	12.4	89	33	35.5
T. 15 N., R. 4 W., in northwest corner section 17, T road south	39	45	21.2	89	34	08.5
T. 15 N., R. 4 W., quarter corner between sections 18 and 19, 4 corners	39	44	39.9	89	34	41.5
T. 15 N., R. 1 W., north part of section 30, T road west	39	43	40.0	89	34	57.2
T. 15 N., R. 5 W., in northeast corner section 25, center of bridge over Sugar Creek	39	43	40.4	89	35	46.2
T. 15 N., R. 5 W., in southeast corner section 23, T road east	39	44	12.8	89	36	57.1
T 15 N., R. 5 W., corner sections 14, 15, 22 and 23, Illinois Central Railroad crossing	39	44	37.7	89	37	48.2
T. 15 N., R. 5 W., quarter corner between sections 15 and 22, 4 corners	39	44	36.6	89	38	38.2
Wabash and Alton railways, crossing of, T. 15 N., R. 5 W., in northeast corner of section 12	39	46	19.0	89	39	09.0
THENCE ALONG WEST BORDER OF QUADRANGLE.						
Athens station, T. 18 N., R. 6 W., in section 36	39	57	53.1	89	43	27.9
T. 17 N., R. 6 W., quarter corner between sections 11 and 12, 4 corners	39	56	20.0	89	43	38.1
T. 17 N., R. 6 W., quarter corner between sections 12 and 13, 4 corners	39	55	27.6	89	43	37.0
T. 17 N., R. 6 W., center section 24, 4 corners	39	54	35.4	89	43	19.0
T. 17 N., R. 6 W., section 23, center of pier of bridge over Sangamon river	39	54	27.5	89	44	32.8
T. 17 N., R. 16 W., quarter corner between sections 27 and 28, T road south	39	53	43.7	89	45	47.3
T. 16 N., R. 5 W., center of southeast quarter section 3, T road W	39	51	46.4	89	45	15.4
T. 16 N., R. 6 W., near center section 10, in grass triangle near T road west, iron post stamped "Prim. Trav. Sta. No. 5, 1905"	39	51	14.2	89	45	32.3
T. 16 N., R. 6 W., north part section 22, 4 corners	39	49	44.7	89	45	30.1
T. 16 N., R. 6 W., north part section 27, T. road west	39	48	44.5	89	45	30.1
T. 16 N., R. 6 W., center section 34, T road north	39	47	39.4	89	45	28.0
Ts. 15 and 16 N., quarter corner section 3, T road south	39	47	13.2	89	45	12.1
T. 15 N., R. 6 W., quarter corner between sections 10 and 15, 1 mile northeast of Curran, near T road north, iron post stamped "Prim. Trav. Sta. No. 6, 1905"	39	45	24.2	89	45	10.3
Wabash and Chicago, Peoria & St. Louis railways, crossing of	39	44	38.1	89	45	43.9

CHAMPAIGN COUNTY—URBANA QUADRANGLE.

The following geographic positions on the United States standard datum were established from primary traverse run in 1905 by Mr. J. R. Ellis, assistant topographer. The line starts from east tower of Illinois State University at Champaign, located by triangulation of the United States Lake Survey; follows Illinois Central Railroad to Tolono; thence east along Wabash Railroad to Homer, connecting with Lake Survey triangulation station, Lynn Grove, and Lake Survey triangulation station chimney at Sidney; thence by wagon road north along border of quadrangle to Thomsonboro; thence southwest along Illinois Central Railroad to starting point.

GEOGRAPHIC POSITIONS ALONG THE ILLINOIS CENTRAL RAILROAD BETWEEN CHAMPAIGN AND TOLONO.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Champaign, east tower "Industrial School," U. S. Lake Survey triangulation station	40	06	32.9	88	13	37.8
Champaign, near southeast corner of Engineer Building, State University, in ground at cross sidewalks near; said building bears N. 26° 15′ W., distant 52.5 feet, iron post stamped "Prim Trav. Sta. No. 1, 1905"	40	06	38.1	88	13	35.2
Champaign, road crossing, 1.25 miles south of (west track)	40	05	40.2	88	14	40.5
Savoy, road crossing, 1 mile north of (west track)	40	04	08.6	88	14	55.0
Savoy station, (west track)	40	03	14.8	88	15	03.5
Savoy station, road crossing, 1 mile south of (west track)	40	02	22.0	88	15	11.9
T. 18 N., R. 8 E., corner sections 11, 12, 13, and 14	40	01	29.3	88	15	15.6
Tolono, in southeast corner of lot at Commercial Hotel; southeast corner of C. H. Bell's store bears N. 28° 30′ E., distant 185 feet; southeast corner of hotel bears N. 4° E., distant 108 feet; iron post stamped "Prim. Trav. Sta. No. 2, 1905"	39	59	06.4	88	15	39.1

GEOGRAPHIC POSITIONS ALONG THE WABASH RAILWAY NEAR TOLONO.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Tolono, road crossing north and south, 1.25 miles east of	39	59	21.5	88	14	15.4
Tolono, road crossing north and south on section line	39	59	37.8	88	13	04.9

GEOGRAPHIC POSITIONS ALONG THE HIGHWAYS BETWEEN TOLONO AND SIDNEY

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 18 N., R. 9 E., corner of sections 20, 21, 28, 29, at crossroads	39	59	45.9	88	11	56.9
T. 18 N., R. 9 E., corner sections 21, 22, 27, and 28, at crossroads	39	59	46.5	88	10	48.7
T. 18 N., R. 9 E., corner sections 22, 23, 26, and 27, at crossroads	39	59	47.1	88	09	40.9
T. 18 N., R. 9 E., corner sections 23, 24, 25, and 26, at crossroads	39	59	47.6	88	08	32.4
T. 18 N., Rs. 9 and 10 E., corner sections 19, 24, 25 and 30, at crossroads	39	59	48.3	88	07	24.1
T. 18 N., Rs. 9 and 10 E., corner sections 25, 30, 31, and 36, at crossroads	39	58	55.6	88	07	23.7
Ts. 17 and 18 N., Rs. 9 and 10 E., corner sections 1, 6, 31, and 36, at crossroads	39	58	03.3	88	07	23.3
Lynn Grove triangulation station: In SW. ¼ of SE. ¼ section 31, T. 18 N., R. 10 E., 3 miles southeast of Philo railway station. Station mark: A stone post 3 feet below surface with another directly over it as a surface mark	39	58	09.85	88	06	35.90
Black, east and west road crossing Frisco Railway	39	58	02.4	88	05	09.0
T. 18 N., R. 10 E., corner sections 28, 29, 32 and 33, at crossroads	39	58	54.7	88	05	07.6
T. 18 N., R. 10 E., in southeast corner section 20, 4 feet from corner of hedge fence, iron post stamped "Prim. Trav. Sta. No. 3, 1905"	39	59	48.7	88	05	08.1
T. 18 N., R. 10 E., quarter corner between sections 16 and 21, crossroads near	40	00	40.4	88	04	33.6
Sidney, Lake survey triangulation station chimney	40	01	25.45	88	04	10.02

GEOGRAPHIC POSITIONS ALONG THE WABASH RAILWAY EAST OF SIDNEY.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Sidney, crossing of Wabash and Frisco railways, 1 mile east of	40	01	30.6	88	03	25.7
Road crossing north and south between sections 11 and 12	40	01	40.5	88	01	43.6
Road crossing north and south between sections 7 and 12	40	01	47.2	88	00	35.0
T. 18 N., R. 14 W., near quarter corner west side section 7, in southwest corner of field and just off right of way, iron post stamped "Prim. Trav. Sta. No. 4, 1905"	40	01	52.9	87	59	39.2

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Ts. 18 and 19 N., R. 11 E., and 14 W., 0.5 mile north of corner to sections 6, 6, 31, and 31, T road west	40	03	28.7	87	59	40.1
Clark school house, crossroads at	40	04	34.7	87	59	40.0
T. 19 N., R. 11 E., 14 W., corner sections 18, 18, and 19, 19, crossroads near	40	05	52.2	87	59	39.8
T. 19 N., R. 11 E., in northeast corner section 18, in corner of field owned by Lou Richards, 2.5 feet soutwest of corner fence post and 133 feet south of Big Four Railway, in limestone 40 x 7 x 5 inches, aluminum tablet stamped "Prim. Trav. Sta. No. 5, 1905"	40	06	45.0	87	59	39.9
T. 19 N., R. 11 E., 14 W., corner sections 6, 6, and 7 and 7, crossroads	40	07	39.0	87	59	39.7
Ts. 19 and 20 N., R. 11 E., 14 W., corner sections 6 and 6 and 31 and 31, crossroads	40	07	31.8	87	59	39.7
T. 20 N., R. 14 W., west corner sections 30 and 31, at Union school house, T road east	40	09	23.9	87	59	39.8
T. 20 N., R. 11 E., 14 W., corner sections 19, 19, and 30, 30	40	10	15.2	87	59	39.6
T. 20 N., R. 14 W., west corner sections 18 and 19, T road east	40	11	06.9	87	59	39.7
T. 20 N., R. 14 W., west corner sections 7 and 18, T road east	40	11	59.1	87	59	39.8
T. 20 N., R. 14 W., west corner sections 6 and 7, T road east	40	12	50.7	87	59	39.9
T. 20 N., Rs. 11 E., 14 W., north cor. sections 6 and 6, T. road south	40	13	29.8	87	59	40.2
T. 21 N., R. 11 E., southeast corner section 25, in southeast corner of Doctor McFarland's garden, corner sections 25, 30, 31 and 36, T. 21 N., Rs. 10 and 11 E., bears S. 43° E., distant 55 feet, iron post stamped "Prim. Trav. Sta. No. 6, 1905"	40	14	23.1	88	00	06.2
T. 21 N., R. 10 E., corner sections 25, 26, 35 and 36; crossroads	40	14	22.6	88	01	15.1
T. 21 N., R. 10 E., corner sections 27, 28, 33 and 34, at Flatville	40	14	22.3	88	02	23.8
T. 21 N., R. 10 E., corner sections 28, 29, 32 and 33; crossroads	40	14	22.2	88	03	32.7
T. 21 N., R. 10 E., in northeast corner section 31, at crossroads, 1.5 feet from corner fence post, iron post stamped "Prim. Trav. Sta. No. 7, 1905	40	14	21.3	88	05	51.7
T. 21 N., Rs. 9 and 10 E., corner sections 30, 31, 36 and 25; crossroads	40	14	21.1	88	06	59.9
T. 21 N., R. 9 E., corner sections 25, 26, 35 and 36; crossroads	40	14	20.8	88	08	08.7
Thomasboro, crossroads 0.5 mile southeast of	40	14	19.6	88	11	02.0

GEOGRAPHIC POSITIONS ALONG THE ILLINOIS CENTRAL RAILROAD BETWEEN THOMASBORO AND CHAMPAIGN.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Milepost 792, east and west road crossing 470 feet south of, east track	40	13	27.0	88	11	44.2
Leverett, east and west road crossing 1 mile north of, east track	40	12	00.8	88	12	20.3
Leverett, east and west road crossing, east track	40	11	21.2	88	12	36.8
T. 20 N., R. 9 E., sections 19 and 20, south corner of, T. road north	40	10	15.6	88	13	12.8
Milepost 787, east and west road crossing, east track	40	09	22.9	88	13	26.3
Milepost 786, east and west road crossing, 230 feet south of, east track	40	08	30.1	88	13	48.3
Illinois Central Railway and Big Four Railway, crossing of, north track Big Four, east track Illinois Central Railway	40	07	17.9	88	14	17.7

Franklin, Hamilton, Saline and Williamson, Counties—Galatia Quadrangle—Continued.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS, AKIN TO DALE.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Three corners, road north to Akin	37	58	13.9	88	44	48.3
Akin, northwest corner of Chas. Crisps' Furniture Store is southeast, northeast corner of Main store is 85 feet west, southeast corner of McGuyers' store is 68.5 feet northwest. 1.5 feet west of sidewalk, in sandstone post, aluminum tablet stamped "Prim. Trav. Sta. No. 5	37	59	20.6	88	44	47.34
T. 6 S., Rs. 4 and 5 E., corner sections 24, 25, 29 and 30	37	58	53.5	88	42	18.7
Three corners, road north, south and east	37	58	27.5	88	41	12.8
House of Granville Hungate, 3 corners, road north	37	58	41.6	88	40	23.4
Little Spring Church, road opposite	37	58	27.0	88	38	34.8
T. 6 S., R. 5 E., center W. ½ sections 25, Flanagan Township, Hamilton county, bears 5.2 feet N. 83° 13′ W. southeast corner post of Perry S. Lee's orchard is 6.4 feet southwest, oak tree bears S. 66° 30′ W., 141.5 feet on north side of highway, in store post 3 feet by 8 by 6 inches, aluminum tablet stamped "Prim. Trav. Sta. No. 6	37	58	27.2	88	36	28.7
T. 6 S., Rs. 5 and 6 E., on north and south township line, middle of east one-half section 25	37	58	27.2	88	35	39.6
T. 6 S., R. 6 E., at corner sections 19 and 30, on township line, 30 feet northwest—black oak tree 8 inches in diameter; 30 feet southwest—telephone pole	37	58	54.6	88	35	39.3
T. 6 S., R. 6 E., corner sections 19, 20, 30 and 31	37	58	54.4	88	34	33.2
T. 6 S., R. 6 E., corner sections 18, 19, 20 and 17	37	59	47.4	88	34	32.7
T. 6 S., R. 5 E., 4 corners sections 16, 17, 20 and 21	37	59	47.3	88	33	27.1
T. 6 S., R. 6 E., corner sections 15, 16, 21 and 22	37	59	47.8	88	32	21.1
T. 6 S., R. 6 E., corner sections 14, 15, 22 and 23	37	59	48.8	88	31	13.8
Dale, southeast of: at middle of, center W. rail L. & N. R. R.	37	59	06.7	88	29	10.5

GEOGRAPHIC POSITIONS ALONG THE ILLINOIS CENTRAL RAILROAD, ELDORADO TO HARRISBURG.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Eldorado, center of track at intersection of Louisville and Nashville and Big Four Railways	37	48	53.8	88	26	04.1
Road crossing	37	48	16.2	88	27	17.7
Road crossing, east and west	37	47	29.51	88	28	48.2
Big Muddy Creek, east end of trestle 427 over	37	45	52.2	88	31	12.5

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR SOUTH BORDER OF QUADRANGLE.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Harrisburg, in southwest corner of court house yard, iron post stamped "Prim. Trav. Sta. No. 1, 1906"	37	44	24.1	88	32	19.8
T. 9 S., R. 6 E., center section 17, crossroads	37	44	25.0	88	34	00.2
T. 9 S., R. 6 E., quarter corner between sections 17 and 18, T road south	37	44	24.4	88	34	33.5
T. 9 S., Rs. 5 and 6 E., quarter corner between sections 13 and 18.	37	44	35.6	88	35	44.2
T. 9 S., R. 5 E., one-sixteenth corner between northeast quarter and southeast quarter section 14, crossroads	37	44	24.9	88	37	07.3
T. 9 S., R. 5 E., quarter corner between sections 14 and 15	37	44	24.4	88	37	58.9
T. 9 S., R. 5 E., one-sixteenth corner between northwest and southwest corners, section 12, north side of road 1.5 foot south of fence line, 14 feet east of fence cornerpost, 3 feet southeast of telephone post, 33.5 feet northeast of center of corners, signboard "16 mi. to Marion; 5 mi. to Harrisburg; 8 mi. to Galatia;" old barn is southeast of 4 corners, iron post stamped "Prim. Trav. Sta. No. 2, 1906"	37	44	24.4	88	38	47.3
Dallasania, 4 corners, one-sixteenth corner between northeast and southeast quarters of section 17, T. 9 S., R. 5 E.	37	44	24.7	88	40	27.2
T. 9 S., Rs. 4 and 5 E., quarter corner between sections 18 and 13, T road east on Salem-Williamson county line	37	44	24.0	88	42	21.7
T. 6 S., R. 5 E., quarter corner between sections 14 and 15	37	44	23.8	88	44	33.4
T. 9 S., R. 4 E., at middle south side of northwest quarter section 15, south side three corners, 2 feet north of wire fence; 82 feet west—fence corner, 530 feet north—southeast corner wagon shed west side of road, 361 feet east—line between a large oak and maple tree on opposite sides of road; road north to Attella, east to Harrisburg, west to Marion; iron post stamped "Prim. Trav. Sta. No. 3, 1906"	37	44	17.8	88	45	24.7

Franklin and Williamson, Counties—Thompsonville Quadrangle.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR EAST BORDER OF QUADRANGLE.

Stations.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 9 S., R. 4 E., sec. 15, at middle of south side of northwest quarter of; 2 feet north of wire fence, 82 feet west—fence corner, 530 feet north—southeast corner wagon shed west side of road, 361 feet east—line between a large oak tree and maple tree opposite sides of road, north to Attela, east to Harrisburg, west to Marion; on south side of 3 corner road, iron post stamped "Prim. Trav. Sta. No. 3, 1906"	37	44	17.8	88	45	24.7
Road crossing, south end of plank bridge	37	45	17.8	88	45	23.3
Four corners	37	45	56.6	88	45	22.6
Station 101	37	46	37.8	88	45	40.0
T. 8 S., R. 4 E., corner secs. 27, 28, 33 and 34, 190 feet southeast of this district No. 8, Grant school-house	37	47	31.4	88	45	40.3
T. 8 S., R. 4 E., sec. 28, 10 feet northeast of large oak tree east of Shiloh Church	37	47	57.7	88	46	13.2
Corinth, center of 3 corners south of, 30 feet northeast of Dogwood tree	37	48	49.1	88	46	37.5
Three corners, 25 feet northwest—large fencepost corner	37	50	34.4	88	46	09.2
Small plank bridge, middle of, east and west, Williamson-Franklin county line	37	51	51.9	88	45	40.2
T. 7 S., R. 4 E., south corner road east, corner secs. 27, 28, 33 and 34.	37	52	44.5	88	45	39.1
T. 7 S., R. 4 E., corner secs. 21, 22, 27 and 28	37	53	37.4	88	45	39.4
T. 7 S., R. 4 E., corner secs. 21, 22, 15 and 16	37	54	29.8	88	45	59.6
Thompsonville, in schoolyard, 52.4 feet to southeast corner schoolhouse, 79. 6 feet north to large elm tree in corner of yard, 82.9 feet northeast to elm tree in corner of yard across street, iron post stamped "Prim. Trav. Sta. No. 4, 1906"	37	54	57.2	88	45	40.2
Three corners, road east	37	56	45.4	88	45	07.0
T. 6 S., R. 4 E., 3 corners in center of south half sec. 27, Franklin county, 35 feet southeast—oak tree; 30 feet northeast—oak	37	57	43.8	88	45	05.1

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR NORTH AND WEST BORDERS OF QUADRANGLE.

Stations.	Latitude.			Longitude.		
	°	′	″	°	′	″
Akin, at southeast corner, northwest corner Chas. Crisp's Furniture store, is southeast, northeast corner of, Main store is 85 feet west, southeast corner of McGuyer's store is 68.5 feet northwest, 1.5 feet west of sidewalk, in sandstone post aluminum tablet stamped "Prim. Trav. Sta. No. 5, 1906"	37	59	20.26	88	44	46.34
T. 6 S., R. 4 E., center sec. 21, road crossing	37	59	20.0	88	46	10.6
T. 6 S., R. 4 E., center sec. 20, 4 corners	37	59	20.0	88	47	17.5
T. 6 S., R. 4 E., and 3 E., on township line between Benton and Easton townships, secs. 19 and 14, north and south township line.	37	59	20.6	88	49	13.1
T. 6 S., R. 3 E., corners between secs. 23 and 24	37	59	17.8	88	50	02.9
T. 6 S., R. 3 E., south half sec. 22, corner of Benton-Thompsonville and Aiken roads, west side of road, southwest corner of plank bridge on Benton Thompsonville road—63 feet northwest; southwest corner of plank bridge on Akin road—34 feet northeast; sweet gum tree blazed on north side on east side of road, 77 feet southeast, elm tree 20 inches in diameter—6 feet northwest, sweet gum tree—6 feet southwest	37	59	06.0	88	51	38.7
Three corners road west	37	59	36.2	88	52	33.7
Benton, center of C. & E. I. R. R. crossing	37	59	52.6	88	54	49.0
T. 6 S., R. 3 E., corner secs. 18 and 19, on township and range line between Benton and Browning townships and Rs. 2 and 3 E	37	59	43.4	88	55	41.7
T. 6 S., R. 2 E., at quarter corner between secs. 13 and 24, iron post stamped "Prim. Trav. Sta. No. 8, 1906"	37	59	41.5	88	56	14.7
Four corners	37	58	49.3	88	56	29.9
T 6 S., R. 2 E., bears N. 49° 30′ E., corner stone secs. 25, 26, 35 and 36	37	57	56.6	88	56	46.5
T 6 S., R. 2 E., quarter corner secs. 26 and 35	37	57	56.1	88	57	19.9
Ts. 6 and 7 S., R. 2 E., quarter corner between secs. 32 and 2	37	57	03.5	88	57	20.4
Middle Branch, center of bridge over	37	55	52.0	88	57	36.1
T. 7 S., R. 2 E., corner secs 14, 15, 22 and 23, a black locust post at 3 corners road south	37	54	26.7	88	57	52.8
Public wells, road corner at, road east to west Frankfort	37	53	47.7	88	57	52.4
T. 7 S., R. 2 E., 3 corners road east, west and north, corner secs. 26, 27, 34 and 35	37	52	39.4	88	57	52.7
T. 7 S., R. 2 E., about center of south half sec. 33, at intersection of C. B. & Q. R. R., and an east west wagon road, iron post stamped "Prim. Trav. Sta. No. 9, 1906"	37	51	59.5	88	59	32.8

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR SOUTH BORDER OF QUADRANGLE.

Stations.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 9 S., R. 2 E., approx. corner secs. 9, 10, 15 and 16, road north	37	44	44.8	88	59	00.0
T. 9 S., R. 2 E., corner secs. 10, 11, 15 and 14	37	44	44.3	88	57	52.7
Marion, corner of Marion ave., and North Court street, southwest corner, 26 feet southeast of is a maple tree at southwest corner of cemetery	37	44	35.5	88	55	55.0
Marion, center of north gate to Marion courthouse yard	37	43	55.1	88	55	35.3
T. 9 S., R. 3 E., corner secs. 17, 18, 19 and 20	37	43	50.6	88	54	37.2
Crab Orchard creek, center of iron bridge over	37	43	51.3	88	53	20.7
T. 9 S., R. 3 E., southwest corner of roads at corner secs. 14, 15, 22 and 23; stone to sec. corner is 47 feet northeast; a big dead oak on southeast corner is 58.5 feet east, soushwest fence corner is 10 feet east, in post stamped "Prim. Trav. Sta. No. 11, 1906"	37	43	50.9	88	51	17.0
Road north	37	43	55.5	88	49	34.9
T. 9 S., R. 4 E., on ½ sec. line sec. 20, crossroads	37	43	51.7	88	47	17.8
Crab Orchard, 3 corners on Marion-Harrisburg road about 2.5 miles east of; on northwest quarter sec. 21, T. 9 S., R. 4 E., 75 feet northwest is southeast corner of red voting house, 20 feet east on corner is cherry tree	37	43	44.6	88	45	31.6

Herrin Quadrangle.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS NEAR EAST BORDER OF QUADRANGLE.

Stations.	Latitude.			Longitude.		
	°	′	″	°	′	″
Road crossing, east and west highway	37	49	12.6	89	00	55.4
Herrin, 0.5 mile north of; center crossing north and east public road and the C. B. & Q. R. R	37	48	50.7	89	01	28.5
Herrin, southeast corner public road and east Maple st	37	48	06.6	89	01	28.5
Stone at road corner road west to Mine No. 2	37	47	08.9	89	01	29.2
T. 8 S., R. 2 E., sections 31 and 32, T. 9 S., R. 2 E., sections 5 and 6, corner of, dead shell-bark tree in door-yard of Mr. Anderson is 95 feet southwest; section corner is about 18 feet north; south rail of electric railroad crossing is 50 feet north; mailbox post of L. Stottar is 3 feet southwest; iron post is 1.5 feet north of fence line, iron post stamped "Prim. Trav. Sta. No. 10, 1906".	37	46	28.7	89	01	12.3
T. 9 S., R. 2 E., corner sections 4, 5, 8 and 9, Baptist church is about 200 feet northeast	37	45	39.9	89	00	07.9
T. 9 S., R. 2 E., approx. corner sections 8, 9, 16 and 17	37	44	45.9	88	00	07.0

Madison and Clinton Counties—Breese Quadrangle.

The following geographic positions were determined by primary traverse in 1905 by Mr. J. R. Ellis. The line starts from an adjusted position on the Belleville quadrangle two miles west of Highland. The line follows Vandalia Railroad to Highland, thence east and south along highways to near southeast corner of quadrangle; thence west along highways to point three miles of New Baden, where line is run west over Southern Railroad to Primary Traverse Station No. 17. The line was tied to Breese and Damainsville triangulation stations, United States Coast and Geodetic Survey.

Breese Quadrangle.

GEOGRAPHIC POSITIONS ALONG THE VANDALIA RAILROAD NEAR HIGHLAND.

Stations.	Latitude.			Longitude.		
	°	′	″	°	′	″
Highland, road crossing 2 miles west of	38	44	02.9	89	42	48.2
Highland, road crossing 1 mile west of	38	44	19.8	89	41	52.9
Highland, road crossing at station	38	44	38.5	89	40	50.5

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Stations.	Latitude.			Longitude.		
	°	′	″	°	′	″
German Cemetery, road at 70 feet due N. to entrance	38	44	33.1	89	39	42.4
Ts. 3 and 4 N., R. 5 W., near corner to sections 2, 3, 34 and 35, 30 feet northwest to sycamore tree, 36 feet northeast to dead black oak	38	44	35.8	89	38	03.5
Ts. 3 and 4 N., R. 5 W., sections 1, 2, 35 and 36, center of road at hedge fence north	38	44	34.7	89	36	56.8
Fred Linenfilser, 400 feet west of his residence, in his pasture, 5 x 5 x 24 inch stone walnut trees bears N. 35° 45′ E., distance 40.4 feet, aluminum tablet in top of stone, stamped "Prim. Trav. Sta. No. 22, 1905"	38	44	35.1	89	36	40.3

GEOGRAPHIC POSITIONS ALONG HIGHWAYS—*Concluded.*

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Ts. 3 and 4 N., Rs. 4 and 5 W., corner sections 1, 6, 31 and 36, also junction Madison, Clinton and Bond counties, 19 feet southwest to west end of small bridge, 29 feet southeast to U. S. mail box.	38	44	35.6	89	35	49.9
T. road north, 15 feet north to center of small bridge	38	44	33.3	89	34	32.2
T. road south, 27 feet northeast to Wm. Frentiger's mail box	38	44	31.3	89	33	23.0
Jamestown, T. road north, one mile west of, 27 feet southeast to dead locust tree	38	44	03.2	89	31	41.8
Jamestown public school grounds, near south line of, 57 feet east of southwest corner of same, southwest corner of school building bears N. 5° E., distant 144 feet, in top of dressed limestone 5 x 5 x 24 inches, aluminum in tablet stamped "Prim. Trav. Sta. No. 23, 1905"	38	43	59.7	89	31	06.9
T. 3 N., R. 4. W., corner sections 2, 3, 10 and 11, at crossroads, 37 feet northwest to corner yard fence, 36 feet southeast to cross on gatepost	38	43	36.1	89	31	07.2
T. 3 N., R. 4 W., corner sections 14, 15, 22 and 23, at crossroads, 30 feet northeast to cross on corner fencepost, 54 feet southeast to milk platform	38	41	51.1	89	31	03.6
T. 3 N., R. 4. W., west corner sections 23 and 26, center of road at fence east just north of schoolhouse	38	40	58.7	89	31	02.3
T. 3 N., R. 4 W., corner sections 26, 27, 34 and 35	38	40	06.5	89	31	01.0
H. Hinkam's farm, T. road west, 42 feet east to wild cherry tree	38	38	56.9	89	31	00.1
State road crossing with north and south road 24 feet north to cross on corner fence post, 63 feet southwest to cross on corner fence post	38	38	31.3	89	31	33.0
Breese, 1 mile north of; in northeast corner of Frank Budde's field, iron post stamped "Prim Trav. Sta. No. 24, 1905"	38	37	30.4	89	31	32.0
Breese, Catholic church spire	38	36	32.0	89	31	44.3
Crossroads, 27 feet northwest to west end of stone culvert, 30 feet southeast to Hem. Ahler's mail box	38	35	47.0	89	32	06.4
Crossroads, 20 feet northwest to west end of culvert, 35 feet southwest to cross on telephone pole	38	34	54.6	89	32	06.1
Germantown, crossroads 1 mile north of; 18 feet north to center of bridge	38	34	02.2	89	32	06.34
Germantown, Catholic church spire	38	33	13.2	89	32	15.9

GEOGRAPHIC POSITIONS ALONG THE SOUTHERN RAILROAD NEAR SHOAL CREEK.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Shoal Creek, center of bridge over	38	32	46.4	89	30	47.5
Road crossing north and south	38	32	28.8	89	29	52.8

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. road south at large wooden cross	38	32	11.6	89	29	02.9
Bartelso, 1.25 miles southwest of; at T road north, in southeast corner of field owned by Herman Soole, nail in blaze on tree bears N. 76° 45′ E., distant 39.8 feet, iron post stamped "Prim. Trav. Sta. No. 25, 1905"	38	31	44.8	89	29	02.8
Murch's school house, T. road east, just south of, 25 feet northeast to cross on wild cherry tree, 31 feet southeast to corner wire fence	38	31	41.8	89	30	24.9
Germantown, T. road south 1.5 miles south of; 33 feet southeast to cross on post	38	31	47.1	89	31	31.8
Center of private road	38	31	44.2	89	33	00.9
T. 1 N., R. 4 W., corner sections 8, 9, 16 and 17, T. road north	38	32	16.1	89	33	12.3
T. 1 N., R. 4 W., corner sections 7, 8, 17 and 18, crossroads, 36 feet northeast to large apple tree, 37 feet southeast to locust tree	38	32	17.5	89	34	18.2
T. 1 N., R. 4 W., east corner sections 18 and 19	38	31	24.9	89	34	17.0

GEOGRAPHIC POSITIONS ALONG HIGHWAYS—*Concluded.*

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
T. 1 N., R. 4 W., corner sections 18 and 19 (west corner), 24 feet west to cross on rail fence	38	31	27.1	89	35	34.9
T. 1 N., R. 5 W., east corner sections 24 and 25, T. road west, 50 feet northwest to cross on fence, 39 feet west to south end of tile culvert	38	30	35.2	89	35	34.9
T. 1 N., R. 5 W, southwest corner section 24, 0.5 mile east of Damiansville, iron post stamped "Prim. Trav. Sta. No. 26, 1905"	38	30	36.3	89	36	42.2
Damiansville, Catholic church spire	38	30	35.8	89	37	24.4
Damiansville school house, 1.25 miles west of; T. road east, 42 feet southeast to northwest corner of school house, 25 feet southwest to northeast end of small bridge	38	30	48.6	89	38	56.4

GEOGRAPHIC POSITIONS ALONG SOUTHERN RAILROAD NEAR NEW BADEN.

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
New Baden, north and south road crossing about 3 miles east of; Southern Railroad crossing	38	31	54.3	89	38	57.0
Milepost 34, private road crossing	38	31	53.2	89	40	37.4
New Baden station	38	31	53.0	89	42	03.1
Milepost 31, road crossing north and south 170 feet west of	38	31	54.2	89	43	58.5
North and south road crossing of Southern Railway, near southwest corner of field of J. B. Freese, iron post stamped "Prim. Trav. Sta. No. 17, 1905"	38	31	55.6	89	45	38.9

Menard and Sangamon Counties—Tallula Quadrangle.

The positions in the following list were determined by primary traverse in June, 1905, by Mr. E. L. McNair, topographer. The line begins at Brown's Crossing, on the Wabash Railway, at the western boundary of Sangamon county, and runs north on or near the county line to about the center of township 18 N., R. 8 W., Menard county, thence east to Petersburg.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Station.	Latitude.			Longitude.		
	°	′	″	°	″	″
Brown's Corners flag station; center of track at railroad crossing	39	43	27.0	89	59	04.4
T. 15 N., R. 8 W., sections 15 and 22, near quarter corner between T road west	39	44	23.7	89	59	04.9
T. 15 N., R. 8 W., section 10, near center of; in triangle of roads, at T road east, iron post stamped "Prim. Trav. St. No. 7, 1905"	39	45	51.5	89	59	05.6
T. 16 N., R. 8 W., near center section 34, 3 corners, T road south.	39	47	34.4	89	59	07.0
T. 16 N., R. 8 W., sections 27 and 34, quarter corner between, T road east	39	48	00.5	89	59	02.6
T. 16 N., R. 8 W., sections 21 and 22, quarter corner between, 3 corners, county line road to north	39	49	19.1	89	59	37.2
T. 16 N., R. 8 W., sections 9, 10, 15 and 16, corner of, T road east	39	50	37.4	89	59	37.8
T. 16 N., R. 8 W., sections 3, 4, 9 and 10, corner; T road east	39	51	29.7	89	59	38.2
T. 16 N., R. 8 W., sections 3 and 4, quarter corner between, 3,corners, T road to west	39	51	55.8	89	59	38.1

GEOGRAPHIC POSITIONS ALONG HIGHWAYS—*Concluded.*

Station.	Latitude.			Longitude.		
	°	′	″	°	′	″
Ashland, 0.75 mile east of; T. 17 N., R. 8 W., sections 27, 28, 33 and 34, corner of; at intersection of roads, at northwest corner, iron post stamped "Prim. Trav. Sta. No. 8, 1905"	39	53	14.4	89	59	39.1
T. 17 N., R 8 W., northwest corner of Sangamon county, T road to east	39	53	55.5	89	59	39.0
T. 17 N., R. 8 W., sections 15, 16, 21 and 22, corner of	39	54	59.6	89	59	39.8
T. 17 N., R. 8 W., sections 9, 10, 15 and 16, corner of, T road west	39	55	51.9	89	59	40.5
T. 17 N., R. 8 W., sections 3 and 4, quarter corner between, 4 corners	39	57	10.3	89	59	41.6
Ts. 17 and 18 N., R. 8 W., sections 4 and 33, quarter corner between	39	57	36.0	90	00	15.4
T road south in western part section 28	39	58	53.8	90	00	43.6
T. 18 N., R. 8 W., sections 27 and 28, quarter corner between, T road south, county line between Menard and Cass counties	39	58	54.2	89	59	42.3
T. 18 N., R. 8 W., sections 21, 22, 27 and 28, corner of	39	59	20.2	89	59	42.4
T. 18 N., R. 8 W., sections 15 and 16, quarter corner between, in grass triangle in center of road south and 25 feet south of center of east and west roads, 450 feet west of farm house of Amos Shoneweise, iron post stamped "Prim. Trav. Sta. No. 9, 1905"	40	00	38.2	89	59	42.6
T. 18 N., R. 8 W., sections 14 and 15, quarter corner between, T road to south	40	00	38.5	89	58	34.9
T road to north, in creek bottom	40	00	51.1	89	57	26.9
T. 18 N., Rs. 7 and 8 W., sections 13 and 18, quarter corner between, 4 corners	40	00	38.6	89	56	17.9
T. road south in western part of section 17	40	00	39.2	89	55	02.8
T. 18 N., R. 7 W., sections 15 and 16, quarter corner between, T road south	40	00	39.2	89	53	03.3
Overhead crossing of Chicago and Alton R. R.	40	00	39.5	89	51	36.8
Petersburg station, Chicago, Peoria & St. Louis Railway, center of track	40	00	41.20	89	50	46.40

Lake County—Waukegan Quadrangle.

In June, 1906, Mr. L. E. Tucker, topographic aid, ran a line of primary traverse around the borders of this quadrangle. Starting at Benton triangulation station, United States Lake Survey, and tieing to primary traverse post No. 1, of 1904.

Waukegan Quadrangle.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Stations.	Latitude.			Longitude.		
Benton triangulation station, U. S. Lake Survey, in N. W. quarter of N. W. quarter of section 7, Benton township. Station mark. A stone post $2\frac{1}{2}$ feet below surface, with another directly over it as a surface mark. Height of station used was 65 feet. Reference marks: Two stone posts, one S. 13° 04′ W., dist. 565.9 meters, one N. 68° 59′ E., 19.65 meters distant. Height of ground at station above mean level of Lake Michigan is 212.6 feet	°	′	″	°	′	″
	42	29	02.88	87	52	43.35
T. 45 N., R. 12 E., quarter corner sections 7 and 8, four corners, North Prairie church on N. E. corner; schoolhouse on northwest corner	42	28	44.2	87	51	46.8
Chicago & Milwaukee and Electric railroad and Winthrop Harbor road, crossing of	42	28	43.9	87	50	41.9

GEOGRAPHIC POSITIONS ALONG CHICAGO AND NORTHWESTERN RAILROAD. ZION CITY TO LAKE FOREST.

Stations.	Latitude.			Longitude.		
	°	′	″	°	′	″
Zion City, corner of Shiloh Boulevard and Elijah avenue, northeast corner of American Express office 90 feet southwest	42	26	59.2	87	49	31.0
Zion City, Shiloh Boulevard and Chicago & Northwestern railroad crossing, west rail	42	26	59.0	87	49	04.4
East and West road crossing	42	23	04.8	87	49	26.3
Waukegan Courthouse	42	21	36.8	87	49	58.4
Chicago & Northwestern railroad and Elgin, Joliet & Eastern railroad, crossing of	42	19	29.9	87	50	20.6
Road crossing, east and west	42	18	32.2	87	50	46.8
Chicago & Northwestern and Chicago & Milwaukee Electric railroads, overhead crossing of	42	16	45.3	87	50	47.9
Chicago & Northwestern railroad, overhead crossing	42	15	27.7	87	50	28.2
Lake Forest, in southeast corner of city hall yard, at corner of Forest and Deerpatt sts., southeast corner of city hall bears N. 63° 30′ W., distance 34.5 feet; northwest corner of Chicago Tel. Co. building bears S. 41° 30′ E., distant 78.3 feet, iron post stamped "Prim. Trav. Sta. No. 12, 1906"	42	15	03.9	87	50	28.7
Chicago & Northwestern railroad and highway crossing	42	14	49.4	87	51	42.1

GEOGRAPHIC POSITIONS ALONG HIGHWAYS.

Stations.	Latitude.			Longitude.		
	°	′	″	°	′	″
Ts. 43 and 44 N., Rs. 11 and 12 E	42	14	23.8	87	53	09.4
Ts. 42 and 44 N., R. 11 E, sections 36 and 35 and 1 and 2	42	14	24.2	87	54	19.6
Ts. 43 and 44 N., R. 11 E., approximate corner sections 35, 34, 3 and 2	42	14	24.7	87	55	30.0
DesPlaines River, on south side of town line road, 9.8 feet southwest of corner of iron bridge across river; an 8 inch oak on opposite side of road is 22 feet north, iron post stamped "Prim. Trav. Sta. No. 13. 1906"	42	14	25.6	87	56	21.5
Milwaukee road and town line, corner of	42	14	25.3	87	56	39.7
Four corners east of railroad crossing	42	14	25.3	87	56	36.2
Wisconsin Central railroad, azimuth of, at station 69	152	01				
Diamond Lake, in southwest corner of schoolhouse No. 76, Union; 5 feet north of schoolyard corner, southwest corner of schoolhouse is 83.6 feet northeast; southeast corner of house of Wm. Einzewam's is 20.5 feet northwest by west, iron post stamped "Prim. Trav. Sta. No. 14, 1906"	42	14	29.1	88	00	13.4
Elgin, Joliet & Eastern railroad, azimuth from station 77	282	51				
Three corners, road east	42	15	18.5	88	00	05.0
Rockefeller, Hotel Cameron, center of street crossing	42	16	25.2	88	00	14.1
Wisconsin Central railroad and highway crossing	42	17	51.7	88	00	17.4
Four corners	42	18	21.5	88	00	15.2
Ts. 44 and 45 N., R. 10 E., and R. 11 E	42	19	39.9	88	00	16.3
Gages corners	42	20	19.2	88	00	16.1
Three corners, road west	42	21	37.8	88	00	06.5
Druses Lake, at 3 corners 600 feet north of north shore of, opposite to Brown's cottage, fence corner on west of road is 29.5 feet south, blazed oak 26.7 feet north; W. C. Brewer's mailbox post No. 4, at corner is 22 feet southeast; iron post stamped "Prim. Trav. Sta. No. 15, 1906"	42	22	17.8	88	01	12.8
Road crossing	42	23	09.6	88	00	14.5
T. 45 N., R. 10 E., sections 1 and 12	42	24	02.1	88	00	14.1
T. 45 N., R. 11 E., corner sections 6 and 7	42	24	02.1	88	00	14.1
Tp. corner	42	24	54.5	88	00	13.6
Four corners, road east and west, northwest and southeast	42	26	39.4	88	00	37.4
Hickory Corners, an oak tree is 35 feet northeast Methodist church is on southwest corner, mailbox No. 69 is 35 feet northwest	42	27	58.1	88	01	01.42
Three corners, road west, schoolhouse on northwest corner	42	28	24.1	88	01	04.5
Pikeville, Wis., 4 corner, south side state line road, west side N. & S. road, fence corner on southwest corner is 30 feet southwest	42	29	44.5	88	01	30.3
T. 1 N., R. 21 E., 50 feet northeast of south corner of sections 34 and 35, N. side state line road, 800 feet northwest Chas. Crawford's house, iron post stamped "Prim. Trav. Sta. No. 1, 1906"	42	29	42.5	87	59	24.6

Declination, N. border 3° 05′; S. border. 2° 34′· W. border 3° 48′

PRIMARY TRAVERSE—JODAVIESS COUNTY—APPLE RIVER QUADRANGLE.

The field work of primary traverse on the Apple River, Galena, Herrin and Murphysboro quadrangles, Jo Daviess, Jackson, Perry, Franklin and Williamson counties, was done by L. E. Tucker, topographic aid, in 1906, but the positions of the following described points have not yet been computed: *

GEOGRAPHIC POSITIONS ALONG RAILROADS AND HIGHWAYS FROM WARREN, APPLE RIVER AND SCALES MOUND TO ELIZABETH.

Stations.	Latitude.	Longitude.
Road crossing		
Apple River, southwest cornor lot 10, block 6, yard of W. H. Smith, southwest cornor of Henry Smith store is E. 64.5 ft.; southwest corner of Henry Smith house is N. 42.2 ft., iron post stamped "Prim. Sta. No. 16, 1906."		
Ts. 29 and 30 N., Rs. 3 and 4 E		
Railroad crossing		
Law station, in front of		
Road crossing north and south		
Underneath crossing		
Scales Mound, southwest corner of school yard, corner Presbyterian church porch is S. E. 93.2 feet, S. E. cor. Catholic church is W. 51 feet; S. W. corner school house porch is N. E. 70 feet., iron post stamped "Prim. Trav. Sta. No. 17, 1906."		
Hesselbacher cheese factory, road leads east		
Northwest corner of factory		
Road west at top of Flint Rock hill		
Gate to Lutheran church		
Corner of Ridge road and Shappville road, mail box of Robert Hill is 50 feet east of station		
Corner Scale Mound-Elizabeth Ridge road and Thompson Mill Galena road		
Three corners road east, mail box of H. J. Ehredt by gate west side of road		
T. 28 N., R. 2 E., S. E. part sec. 26, in southwest corner of 3 corners near school house No. 4, (Mt. Morley); Schol House is 119 ft. N. 41° 00′ E., a blazed oak is 124 ft. W., an oak stump with mailbox of E. E. Sanderson, Louis Werner S. 41° E., and Henry Hess is 41.5 ft on east side of road, iron post stamped "Prim. Trav. Sta. No. 18, 1906."		
Three corners road east; mailbox of Will Brickner is 35 ft. E. of station		
Hickory Grove School House, Elizabeth Township, center of road in front of		
4 corners, center of; mailbox of H. Rees on southeast corner		
Corner of Elizabeth, Galena and Scales Mound Ridge road bears S. 31° 15′ W		
Elizabeth, corner Main and Myrtle sts., corner Black Hawk Bldg. bears S. 89° 36′ W. 35 ft.; corner Illinois Bldg. bears N. 12° E., 45 feet		

GEOGRAPHIC POSITIONS ALONG HIGHWAYS TO SOUTHWEST CORNER QUADRANGLE THENCE TO MASSBACH.

Stations.	Latitude.	Longitude.
Crossing of Chicago Great Western Railway		
T. 27 N., R. 2 E., quarter corner between secs. 25 and 36 (Approx. cor. not found)		
T. 27 N., R. 2 E., and T. 26 N., R. 2 E., quarter corner between secs. 36 and 1, respectively		
Pleasant Hill School House, Hanover Township, being S. W. corner of quadrangle; east side of school yard fence, 43 feet south of N. E. corner of school fence, 126.6 feet north of large white oak, at southeast corner of school yard; another large white oak is 11 feet S. E. of B. M.; school fence is 4 feet west; iron post stamped "Prim. Trav. Sta. No. 19, 1906."		

* These will be furnished on request.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS—*Concluded.*

Stations.	Latitude.	Longitude.
T. 26 N., R. 3 E., approx. corner secs. 7, 8, 17 and 18, road south.		
T. 26 N., R. 3 E., approx. corner secs. 8, 9, 16 and 17, Derinda Center, 4 corners		
T. 26 N., R. 3 E., approx. corner secs. 9, 10, 15 and 16, west end of iron bridge over Big Rush Creek		
Massbach, 600 feet south of P. O.; road north, south and west; (route south;) east side of road at three corners		
T. 26 N., R. 3 E., on south line sec. 14, 3 corners O. 5 mile south of Massbach P. O.		

GEOGRAPHIC POSITIONS ALONG HIGHWAYS VIA MORESVILLE TO WARREN.

Stations.	Latitude.	Longitude.
T. 26 N., Rs. 3 and 4 E., corner secs. 13 and 34, and 18 and 19 respectively bears S. 73° 00′ E., 70 feet; (corner approx.), southeast corner of schoolyard of Camp Creek Union School 14. DerindaTownship, S.E. cor. school house bears N. 33° 00′ W. 81 ft.; 16 inch oak bears N. 42° 30′ E., 52 feet; iron post stamped "Prim. Trav. Sta. No. 20, 1906."		
T. 26 N., R. 4 E., corner secs. 17, 18, 19 and 20		
T. 26 N., R. 4 E., N. E. part sec. 20, 4 corners on Galena-Dixon road, private road west		
Pleasant Valley Township, T road at Carroll School House No. 21		
Center of road in front of Pleasant Valley Town Hall		
T. road south just west of white schoolhouse		
T. 26 N., R. 5 E., northwest quarter sec. 7, on south side of Savanna-Freeport road, 150 feet northeast with corner with Union Church road; a 22 inch wild cherry is 9.6 ft. S. 16° W. N. E. corner iron bridge over Middle Plum River is S. 38° 30′ E. 366 ft.; iron post stamped "Prim. Trav. Sta. No. 21, 1906."		
Corner of Pleasant Valley, Stockton, Ward Grove and Berriman Townships, (Approx.) 3 corners road east, Ts. 26 and 27 N., Rs. 4 and 5 E.		
T. 27. N., R. 5 E., southwest corner sec. 30, road east		
T. 27 N., R. 5 E., sec. 30, southwest corner of; 3 corners, road west		
T. 27 N., R. 5 E., sec. 18, southwest corner, road east		
T. 27 N., R. 5 E., southwest corner section 7, crossing of Great Western Railway		
T. 27 N., R. 5 E., southwest corner section 6, Rush Township, in school yard of school house 82, just south of plank walk leading from yard gate to school house, 1 foot west of fence S. E. corner school house bears S. 73° W., feet; flag pole is 7 feet south		
T. 28 N., R. 4 E., corner sections 13 and 24, 4 corners at Chelsea church		
T. 28 N., R. 5 E., town of Nora, corner sections 18 and 19, road east		
T. 28 N., R. 4 E., town of Rush, corner sections 12 and 13 road west	do	
T. 28 N., R. 5 E., (Nora) corner sections 6 and 7, 4 corners at Pucketts schoolhouse		
T. 28 N., R. 4 E., (Rush) corner sections 1 and 12		
Ts. 28 and 29, Rs. 4 and 5 E., 4 corners road west		

Primary Traverse.

JoDaviess County—Galena Quadrangle.

GEOGRAPHIC POSITIONS ALONG RAILROAD AND HIGHWAYS FROM SCALE MOUNDS VIA COUNCILHILL TO MILLBRIG.

Station.	Latitude.	Longitude.
Scales Mound, 0.7 mile west of; center of wagon bridge over I. C. Railroad		
T. 29 N., R. 2 E., approx. corner sections 22, 23, 26 and 27, 5 feet east of		
Center of iron bridge		
Illinois-Wisconsin state line at elbow corner road west, Veta Grand; mail box of Wm. Haskins is 30 feet northwest, corner of state line fence with east road fence is 20 feet east		
Stone at state line, road north into Wisconsin		
T. 29 N., R. 2 E., approx. corner sections 15 and 16, Illinois-Wisconsin state line, road south		
Town of Councilhill, center of road opposite school house No. 92		
West quarter corner section 19, T. 29 N., R. 2 E., bears N. 43° 00′ E., 5 feet from station; east quarter corner section 24, T. 29 N., R. 1 E., bears S 30 feet from station		
Councilhill, three corners at stone blacksmith shop; road south, east and west		
Councilhill, 0.5 mile southwest of; mail box of James E. Welch on three corners		
T. 29 N., R. 1 E., east ½ section 27, and northeast corner of three corners 0.5 mile east of Mulbrig		
Just east of ruins of old stone church; corner of fence is S. 50° W., 8 feet; mail box of T. Trevarthen is S. 45° 00′ W., 75 feet; distance to fence line is 1.5 feet; iron post stamped "Prim. Trav. Sta. No. 23, 1906"		

GEOGRAPHIC POSITIONS ALONG HIGHWAYS VIA TURNPIKE TO STATE LINE, THENCE TO GALENA, THENCE VIA HORSESHOE MOUND TO BLANDING.

Station.	Latitude.	Longitude.
Crossing of road and C. & N.W. Railroad		
State Line, Wisconsin-Illinois, T. 29 N., R. 1 E., on north and south wagon road, on west half of north line section 15. (Here the line turns west across field to State Line road		
Intersection of fourth prime meridian with Illinois-Wisconsin state line		
South side of State Line road at corner Galena-Hazel Green turnpike, 1 foot north of fence line, 10 feet east of fence corner, a blazed maple on state line bears N.W., 77.7 feet; a cottonwood bears N. 53 feet; iron post stamped "Prim. Trav. Sta. No. 24, 1906"		
Four corners, 20 feet west of center of turnpike, in center of road west to Excelsior Mill		
T. 29 N., R. 1 W., center section 23 (approx.)		
T. 29 N., R. 1 W., section 28, east part of southeast quarter of; on south side of Bodell four corners, Menominee township (formerly Excelsior Mill), S. E. corner Bodell's front yard fence bears N. 1° 00′ W. 104 feet; mail box of Gerhard Bussen bears N. 30° 30′ E. 87 feet; iron post stamped "Prim. Trav. Sta. No. 25, 1906"		
T. 28 N., R. 1 W., about center of northeast quarter of section 2; corner of Galena-Hazel Green and road to Excelsior, northwest fence corner is N. 62° W., east fence of turnpike is 18 feet east; Four Mile house is on southwest corner		
T. 28 N., R. 1 W., intersection of Galena turnpike and section line between sections 2 and 11, road west, Cottage Grove school house on east side of turnpike		
Corner sections 11, 12, 13 and 14 bears north 130 feet		
Galena, in most easterly corner of court house yard; east corner of court house bears S. 89° 00′ W., 24.5 feet, square stone on northwest corner of Bench and Meeker streets bears S. 80° 00′ E., 14.7 feet, iron post stamped "Prim. Trav. Sta. No. 26"		
Galena, just east of postoffice building, north end of iron bridge over Galena river		
The line here forms a circuit run for the purpose of connecting with the Horseshoe Mound triangulation station		
Galena, center of intersection of I. C. Railroad and C., B. & Q. Railroad at switch tower		

GEOGRAPHIC POSITIONS ALONG HIGHWAYS—*Concluded.*

Station.	Latitude.	Longitude.
Galena Junction depot		
East and west road crossing C., B. & Q. R.R. culvert No. 16. 812, just north of crossing		
Railroad crossing northwest and southeast		
Blanding station, 1 mile northwest of; railroad crossing		
Blanding, on west side of C., B. & Q. R. R. at elbow corner front of postoffice, northeast corner postoffice is 74 feet southwest; east corner of Mrs. Batie's house is west 44 feet, northwest corner of Blanding station is 44 feet east; iron post stamped "Prim. Trav. Sta. No. 27, 1906"		

GEOGRAPHIC POSITIONS ALONG HIGHWAYS VIA HANOVER TO PLEASANT HILL.

Station.	Latitude.	Longitude.
T. 26 N., R. 1 E., road crossing north and south on line between sections 11 and 12		
T. 26 N., R. 1 E., section 12, southwest part of; crossing with east and west road. (Here road leaves railroad and runs easterly to Hanover.)		
T. 26 N., R. 1 E., section 12, southeast part of; three corners, road east to Hanover; road west and northwest to Blanding		
Road south, east and west, three corners		
Large oak tree at three corners north side of road bears 50 feet N. 62° 30′ W.; road east to Hanover, west to Blanding and southwest to Hanover station		
Hanover, at southwest corner of hotel piazza wall; northeast corner of Hanover Manufacturing Co. brick block bears S. W. 87.4 feet; northwest corner of Miller & White's brick bears store bears S. 616 feet; iron post stamped "Prim. Trav. Sta. No. 28, 1906"		
Corner Jefferson street, Pleasant Hill road and Savanna road; Holy Face Catholic church is in southwest		
Three corners, road west to Hanover, east to Pleasant Hill, north along Apple river to Elizabeth		

Primary Traverse.

Franklin, Jackson, Perry and Williamson Counties—Herrin Quadrangle.

GEOGRAPHIC POSITIONS ALONG ILLINOIS CENTRAL RAILWAY, CARBONDALE TO DUQUOIN, THENCE ALONG HIGHWAYS TO BENTON.

Stations.	Latitude.	Longitude.
Road crossing east and west		
East and west road crossing		
Underneath crossing of Illinois Central and St. L., I. M. & S.R.R.		
Ward station, road crossing		
East and west road crossing		
Hollidaysboro coal mine, road crossing just south of, east and west		
East and west road crossing, 125 feet east of crossing is a T road northeast and west		
Elkville station platform, 1 foot north of; 10 feet west of northeast corner, 12 feet east of northwest corner, 16 feet east of east rail Illinois Central R. R., 170 feet north of semaphore post at Elkville station, iron post stamped, "Prim. Trav. Sta. No. 34, 1906"		
East and west road crossing		
T. 6 S., R. 1 W., half section line section 29, east and west road crossing 85 feet west of half section line, road south along I. C. R. R		
East and west road crossing		
Duquoin station, 37 feet northwest of northwest post of station, on west rail of east track, main line		

GEOGRAPHIC POSITIONS ALONG ILLINOIS CENTRAL RAILROAD—*Concluded.*

Stations.	Latitude.	Longitude.
Duquoin, in east brick wall of Exchange bank of G. S. Smith & Co., 4 feet above level of sidewalk, 2 feet south of east door of bank opening into Division street, aluminum tablet stamped "Prim. Trav. Sta. No. 32, 1906"		
Five corners		
Ebenezer school house, opposite; T corner road south, approx. center section 12, T. 5 S., R. 1 W		
North rail at crossing		
T. 6 S., R. 1 W., section 11, T corner road north		
T. 6 S., R. 1 W., quarter corner between sections 11 and 12, 4 corners, approx. quarter corner		
Three corners road east to Benton, south to Mulkeytown, west to Duquoin		
Little Muddy river, center of iron bridge over		
T. 6 S., R. 1 E., section line sections 4 and 5, just south of Mr. Lindsay's house on, 45 feet west of 3 corners		
Corner sections 4, 5, 8 and 9, 22 feet southeast of; on elbow corner at Kane Creek school house		
T. 6 S., R. 1 E., corner sections 8. 9, 16 and 17, 0.25 mile north of; 4 corners		
T. 6 S., R. 1 N., approx. corner sections 16, 17, 20 and 21, bears S. 30° 00′ W. 28 feet; in northeast corner of four corners, just east of The Blue Grass school house, district No. 30; nail in blaze on oak tree at southeast corner of road bears south 83 feet; a nail in blaze on oak tree at southwest corner of road bears south 36° 00′ west 83 feet, iron post stamped "Prim. Trav. Sta. No. 33, 1906"		
T. 6 S., R. 1 E., corner sections 15, 16, 21 and 22, approx., T corner road north		
T. 6 S., R. 1 E., corner sections 14, 15, 22 and 23, road north		
T. 6 S., R. 1 E., quarter corner between sections 14 and 23, road south		
T corner, road south to Christopher, west to Duquoin, north to Sesser station		
T. 6 S., R. 1 E., section 24, T. 6 S., R. 2 E., section 19, in middle of north half of section line between, on township line		
T road south, a black locust tree bears southeast 30 feet		
T. 6 S., R. 2 E., 3 corners section line between sections 19 and 20, midway between north full corner and quarter corner		
T. 6 S., R. 1 E., section line between sections 20 and 21, north and south road crossing		
House of W. M. Wolf, north side of, about 150 feet south of I. C. R. R., east of wagon road, bears S. 71° 00′ 141 feet; iron post stamped "Prim. Trav. Sta. No. 34"		

GEOGRAPHIC POSITIONS ALONG SOUTH BORDER, CARBONDALE TO B. M. 10, ALONG ILLINOIS CENTRAL RAILROAD.

Station.	Latitude.	Longitude.
Center of small bridge over creek, north		
Elbow corner, road south and west		
Three corners, road south		
T. 9 S., R. 1 W., approximate center of S.W. quarter section 13, 25 feet east of; 3 corners, road south		
T. 9 S., Rs. 1 E., and 1 W., sections 18 and 13, respectively, at middle south half of section line between, Jackson-Williamson county line, 10 feet west of		
T. 9 S., R. 1 E., corner sections 7 and 18, stone post, corner Jackson-Williamson county line, bears N. 50° W., 6 feet; road east to Carterville		
T. 9 S., R. 1 E., sections 5 and 8, quarter corner between		
Four corners		
Carterville City School yard, southwest part of, 1 foot north of east and west sidewalk, 1.3 feet west of line of north and south crosswalk across alley, west side of cinder walk south from schoolhouse is 30 feet east; southwest corner of brick schoolhouse bears N. 57° 00′ E., 104 feet, iron post stamped "Prim. Trav. Sta. No. 31, 1906"		

GEOGRAPHIC POSITIONS ALONG SOUTH BORDER—*Concluded.*

Station.	Latitude.	Longitude.
Ts. 8 and 9 S., R. 1 E., corner sections 34 and 35; 2 x 3 stone post in center of 4 corners, 18 feet southwest of blazed sycamore tree; section corner bears S. 87° 00′ W., 10.5 feet from station..		
Road north, quarter corner between sections.....		
Ts. 8 and 9 S., Rs. 1 and 2 E., lane north, stone post at corner....		
B. M. No. 10, 1906. T. 8 S., R. 2 E., sections 31 and 32; T. 9 S., R. 2 E., sections 6 and 5, near corner.....		

Primary Traverse.

Jackron and Perry Counties—Murphysboro Quadrangle.

GEOGRAPHIC POSITIONS ALONG HIGHWAYS FROM DUQUOIN TO DENMARK, THENCE TO SAND RIDGE, THENCE TO FOUNTAIN BLUFF.

Station.	Latitude.	Longitude.
T. 6 S., R. 1 W., section 18, T. 6 S., R. 2 W., section 13, quarter corner between.....		
T road south, opposite, stone in road.....		
T. 6 S., R. 2 W., approximate quarter corner between sections 14 and 15.....		
T. 6 S., R. 2 W., road south, private road north, center section 16.		
T. 6 S., R. 2 W., quarter corner between sections 17 and 18, T road south		
T. 6 S., R. 2 W., center section 18, southwest corner of 4 corners, northeast fence corner bears N. 45° 00′ W., 6 feet; iron post stamped "Prim. Trav. Sta. No. 35, 1906".....		
T. 6 S., Rs. 2 and 3 W., quarter corner on township line between, is 30 feet south of.....		
T. 6 S., R. 1 W., quarter corner between sections 13 and 14, T road south		
Sections 17 and 18, quarter corner between		
T. 6 S., R. 3 W., section 17, center of; T road north.....		
T. 6 S., R. 3 W., quarter corner between sections 17 and 18, bears N. 18 feet; station is an elbow corner road south and east, wood road east		
T. 6 S., Rs. 3 and 4 W., corner sections 18, 19, 13 and 24.....		
Road south at Denmark.....		
Denmark, 1 foot on west side of old brick church now owned by E. Anderson and 5 feet south of northwest corner: northeast of Free Baptist Church bears S.W. 90 feet, iron post stamped "Prim. Trav. Sta. No. 36, 1906." (Bench mark is connected to main line).....		
T. 6 S., R. 4 W., sections 23 and 26, quarter corner between, T road east.....		
T. 6 S., R. 4 W., sections 26 and 35, quarter corner between.....		
T. 6 S., R. 4 W., corner sections 25, 26, 35 and 36.....		
T. 6 S., R. 4 W., section 36, southeast corner L corner road west and south.....		
Ts. 6 and 7 S., Rs. 3 and 4 W., intersection of township line with Jackson and Perry county line, crossroads.....		
T. 7 S., R. 3 W., sections 5 and 6, quarter corner between.....		
Sugar Hill school house, northeast corner, T. 7 S., R. 3 W., sections 5 and 8, quarter corner between.....		
T. 7 S., R. 3 W., center section 8, T road east.....		
T. 7 S., R. 3 W., corner sections 19, 20, 29 and 30, bears 17 feet S.E. L corner, turn west at M. & L. R. R. crossing		
Ava, in southeast corner of M. & O. R. R. depot lot, 1 foot west of sidewalk, southeast corner of station bears N. 76° 00′ N. 82 feet; southeast corner of station platform is 30 feet northwest, northwest corner of cement sidewalk on south side of street in S. 47 feet; iron post stamped "Prim. Trav. Sta. No. 37. 1906"..		
Ts. 7 and 8 S., Rs. 3 and 4 W., corner T road east.....		
T. 8 S., R. 3 W., $\frac{1}{16}$ corner of northeast quarter section 8, between section 8, T. 8 S., R. 3 W., and section 5, R. 7 S., L corner		
Sodom school house, T road east, northeast corner church on southeast corner		
T. 8 S., R. 3 W., corner sections 16, 17, 20 and 21, bears S. 4° 30′ E., 316 feet and east 1364 feet from station.....		

GEOGRAPHIC POSITIONS ALONG SOUTH BORDER OF QUADRANGLE FROM FOUNTAIN BLUFF TO CARBONDALE ALONG ILLINOIS CENTRAL RAILROAD.

Statton.	Latitude.	Longitude.
T road north, turn east		
T road southeast across Kincaid creek; turn southeast, ford creek		
Three corners, turn southeast		
Waldbeiser school house district No. 65, Jackson county, T road east		
T. 8 S., R. 3 W., center section 32, bears S. 2° 00′ E. 60 feet		
Grove and Sand Ridge branch of I. C. R. R; turn south and follow railroad to Sand Ridge Junction		
East and west road crossing		
Crossing of I. C. R. R. and St. L., I. M. & S. R. R.		
Station 6 (line from Fountain Bluff to B. M 10)		
Leo Rock station, at tower east of; crossing of I. C. R. R and St. L., & I. M. R. R.		
Miss. River Com B. M. No. $\frac{23}{1}$		
North rail I. C. R. R.. center of St. L. & I. M. R. R. crossing		
Sand Ridge Junction, 3 feet northeast of switch bar, on north rail of I. C. R. R		
Center pier I. C. R. R. bridge over Big Muddy river		
Private road crossing		
House of J. G. Henson near private road crossing		
Murphysboro, 1 mile southeast of; 0.25 mile west of Mobile & Ohio R. R. crossing; from station 45 east, cattle guard is 22 feet; west cattle guard 34 feet; on south rail of I. C. R. R. at road crossing		
Mobile & Ohio R. R. crossing		
Murphysboro, in northwest corner of court house yard, 1 foot south of north iron fence, 1.5 feet east of west iron fence, iron post stamped "Prim. Trav. Station No. 29, 1906"		
T. 9 S., R. 2 W., sections 4 and 9, quarter corner between		
Crossing Illinois Central Railroad		
Corner Murphysboro-Jonesboro-Carbondale roads, T. 9 S., R. 2 W., west side section 10		
Pleasant Grove Church, in front of; opposite Pleasant Grove school house, north side of road		
T. 9 S., R. 2 W., sections 13 and 24, at middle of west half section line; 35 feet southeast from U. S. mail box front of Mr. Easterly's house, T road, north, south and east		
T. 9 S., R. 2 W., section 24, northeast corner of; corner stone to, bears N. 58° 15′ E., 33 feet; road north on township line		
T. 9 S., R. 1 W., sections 17, 18, 19 and 20, 3 corners, road north.		
Carbondale, northwest corner of I. C. R. R. park, 12 feet east of iron water stand, 2 feet east of iron fence, 6 feet south of iron fence, iron post stamped "Prim. Trav. Sta. No. 30, 1906"		

Office Work, 1905-1906.

Computations and Draughting.

Mr. S. S. Gannett, geographer, of the United States Geological Survey, was in charge of the division of triangulation and computation. During the year 1905-6 the following computations were made:

For the Springfield, Tallula, Urbana, Mahomet, Belleville, Breese, and Wheaton quadrangles, in Champaign, Clinton, DuPage, Madison, Menard, and Sangamon counties, 1,411 latitudes and departures and 336 geographic positions were computed. Level circuits in the Breese, Belleville, Eldorado, Mahomet, New Haven, Springfield, and Urbana quadrangles, in Champaign, Clinton, Gallatin, Madison, Menard, Sangamon, Saline, and White counties, were adjusted, and the office computations of the precise line from Pekin to Champaign was made.

All of the topographic surveying of the field season of 1905 was carefully drafted in ink during the winter of 1905-6 and preliminary photolithographic copies were made for distribution of the completed sheets. The preliminary road traverse was adjusted on Breese and Wheaton sheet prior to sketching topography in the field.

During the present office season, 1906-7, computations will be made of the results of primary traverse and precise levels and drafting of topographic maps will be done.

Engraved Sheets.

All the atlas sheets completely mapped during the field season of 1905 were turned over to the engraver for publication. Those which have been published are the following, representing a land area of 657 square miles:

Sheet Name.	Counties.	Square Miles.
Eldorado	Gallatin, Hamilton, Saline, White	235.66
New Haven (Illinois, Indiana, Kentucky)	Gallatin, White	192.78
Urbana	Champaign	228.40
Total		656.84

Springfield will be published by January first.

Photolithographic Editions.

In addition to the sheets engraved and published in colors, as listed above, all sheets completed during the year 1905 were published in preliminary photolithographic form for dissemination in 1906. All these are in the hands of the engraver pending issuance in colors. They are as follows:

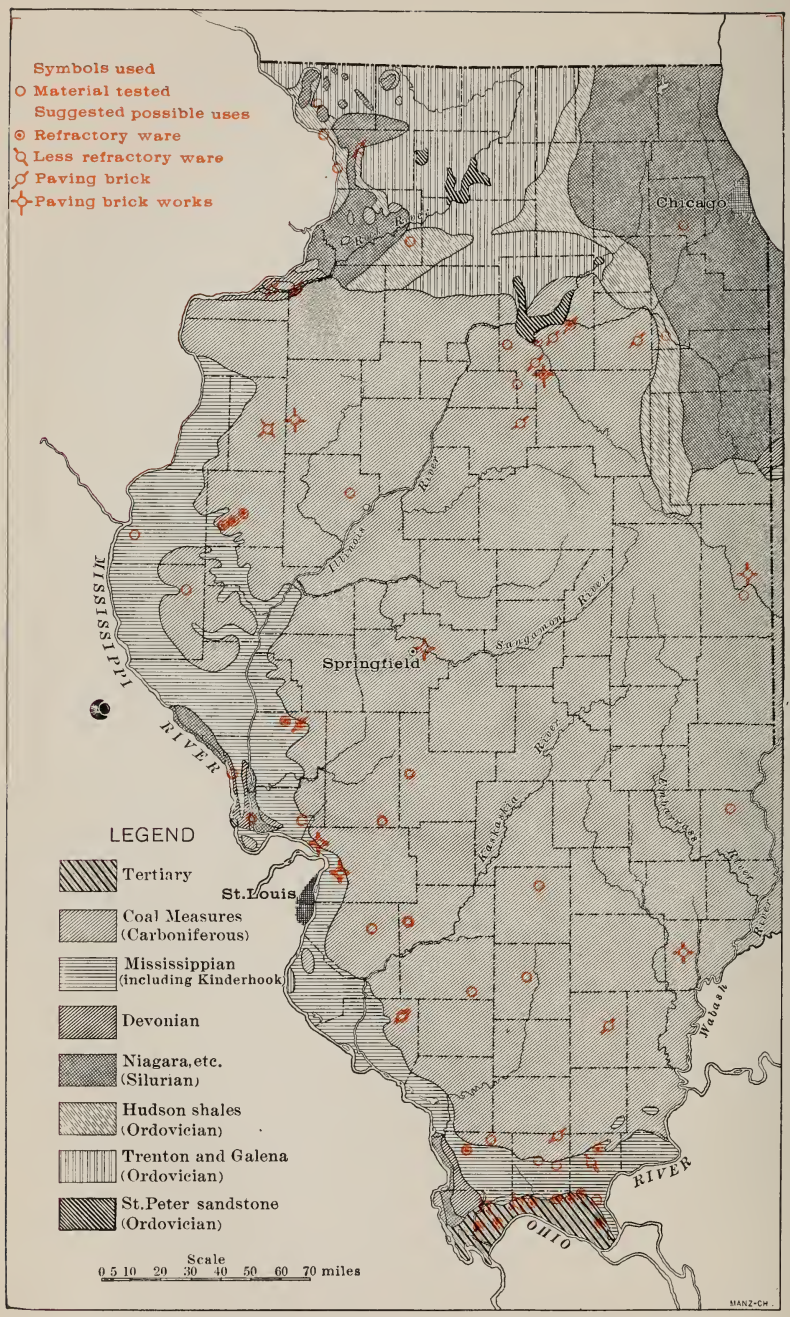
Sheet Name.	Counties.	Square Miles.
Belleville	Madison, St. Clair	233.28
Mahomet	Champaign, Piatt	228.40
Springfield	Logan, Menard, Sangamon	229.22
Total		690.90

PRELIMINARY INVESTIGATION OF ILLINOIS FIRE CLAYS.

(By Ross C. Purdy and Frank W. DeWolf.)

Contents.

Contents—Concluded.



Map showing distribution of fire clays and shales tested.
(Base map furnished by U. S. Geological Survey.)

Introduction.

Illinois has enjoyed no great reputation for the production of fire clay or refractory ware, since by far the larger part of that used within the State has been shipped in. There are, however, a number of localities at which raw fire clay or its finished ware are being produced in increasing amounts. The development of the industry is indicated by the following table, compiled from the incomplete data now in the survey's possession. For the most part local clays are used entirely in these wares:

Locality.	Product.
Carbon Cliff	Tile, fire clay and fire brick
Coal City	Fire clay
Colchester	Ssoneware clay
Deer Park	Fire clay
Drake	Fire clay
Golden Eagle	Fire brick
Lowell	Stoneware
Macomb	Clay and stoneware
Metropolis	Stoneware
Monmouth	Stoneware
Morton	Stoneware
Niles Center	Fire proofing
Ottawa	Fire clay
Park Ridge	Stoneware clay
Rock Island	Fire clay
Round Knob	Fire clay and stoneware
Streator	Fire clay
Tennessee	Clay
Twin Bluffs	Fire proofing
Utica	Fire brick and fire clay
Whitehall	Stoneware
Winchester	Stoneware

The annual output of fire clay and fire clay products in the State has a value probably in excess of $500,000.

Scope of Investigation.

In response to the evident need of the public for knowledge of Illinois clays which may be of value for refractory purposes, an investigation was undertaken during the past season by members of the survey in coöperation with the Department of Ceramics at the State University, Prof. C. W. Rolfe in charge. The collection of the field material and notes was undertaken by the survey, while the laboratory work fell to the University. It was evident at the start that more than a preliminary examination was precluded by plans already adopted for work along other lines, and that study could not be made at this time of several factors whose consideration is essential in a thorough examination into the values and possible uses of fire clays. It was thought, however, that the laboratory study would give a clue to the probable value of certain clays, and that a field examination would indicate the probable extent of their occurrence and the course to be pursued in their development. Accordingly, field and laboratory study was made of some eighty-five clays found within the State at the lo-

calities indicated on the accompanying map (Plate 3). Doubtless these are but a few of the places where clays of possible value deserve attention.

The field examination was carried on in connection with other work by several members of the survey,* under varying conditions and with scant time for detailed geologic work. Certain of the more convenient localities of clay production were visited, and brief examinations made of locations and geologic occurrences with a view to ascertaining the extent of development of the deposits. Samples were taken at favorable points to show the character of the beds. It was desired to make these representative of the various clays, either of the total thickness exposed or of certain definite portions of probable value. In a few instances samples were not seen in place by the survey's representatives, but were collected second-hand. Such special cases are mentioned in the notes which follow. Brief examinations were made of many of the plants where Illinois clays are being utilized, in order to learn the general methods employed and the variety of wares produced. In the laboratory, prelimniary, chemical and physical tests were made of the more promising samples, but as already stated, there are many desirable lines of investigation which could not be followed at this time.

Among the further determinations which would be of value in this connection may be mentioned the following:

Size of grain in the portions of the clay finer than 200 mesh grade.

Chemical and mineralogical constitution and pyrometric properties of the several groups into which each clay can be divided on the basis of fineness of grain.

Rates of vitrification of heat range between vitrification and fusion.

The exact effect on the clay as a whole of reducing and oxidizing conditions in the furnace.

Tensile strength of unburned and burned brickettes, with and without admixture of grog.

The influence of addition of sand on the various properties of the clays.

Coefficient of expansion and contraction.

Ability to sustain a load at high temperature.

Tests Undertaken.

It was impossible to undertake at this time so complete an investigation. The following determinations were, however, made:

1. Chemical analysis.
2. Fusion point.
3. Range from vitrification to fusion.
4. Fineness of grain.
5. Slacking.
6. Plasticity.
7. Drying and burning.

The tests were made under the immediate direction of Mr. Ross C. Purdy and his associate, Mr. J. F. Krehbiel, and the chemical analyses under the direction of Professor S. W. Parr.

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*Field examinations were conducted by the assistants in the following list, and field samples bear initials indicating the name of the collector: F. W. DeWolf, H. B. Fox, F. F. Grout, E. T. Hancock, F. B. Van Horn.

The localities visited in search of fire clays included the following counties: Alexander, Calhoun, Carroll, Fulton, Greene, Grundy, Hardin, JoDaviess, Johnson, LaSalle, Marshall, Massac, McLean, Peoria, Pope, Pulaski, Randolph, Rock Island, Union, Will, Woodford.

Chemical analyses.—The selection of chemical tests to be made was determined by the following considerations:

(1) Because of the lack of time and doubtful importance of ascertaining the exact character and quality of the alkaline earths, they were not determined except in those clays in which they exceeded 5 per cent of the total weight. The total amount of alkalies and alkaline earth fluxes can be approximated by taking the difference between the "total" as reported, and 100. In all cases a test was made for lime, but it was detected in few of the clays, and only as a "trace."

(2) Since iron is usually the predominant flux present, and since at high temperature under either oxidizing or reducing conditions it is considerably the most active flux, it was essential that it should be determined.

(3) Inasmuch as titanium is now recognized as being a flux of considerable potency, and as it is an ingredient of nearly every clay, it was considered important that it should be determined.

Table 1 shows the molecular formulæ of the several clays, calculated from the analyses. This table shows the molecular amount of each oxide present and permits of the ready calculation of the acidity of the clays.

TABLE I—*Molecular Formulae of Clays.*

Sample Number.	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	Fusion Point.
H 8	4.34	1.00	0.085	0.085	28
H 9	25.62	1.00	0.058	0.17	Not reached
H 10	8.45	1.00	0.046	0.11	30
H 41	5.26	1.00	0.046	0.076	29–30
H 42	5.14	1.00	0.047	0.095	29
H 43	3.23	1.00	0.034	0.069	30
H 44	9.55	1.00	0.059	0.093	31–32
H 45	16.82	1.00	0.061	0.012	28–29
H 46	9.18	1.00	0.046	0.082	28–29
D 10	1.83	1.00	0.027	0.075	Not reached
D 11	2.64	1.00	0.021	0.131	Not reached
D 12	3.21	1.00	0.026	0.117	Not reached
D 13	2.15	1.00	0.021	0.101	Not reached
D 14	2.63	1.00	0.018	0.109	Not reached
D 28	5.10	1.00	0.046	0.093	32
D 29	6.65	1.00	0.053	0.097	29
D 30	4.57	1.00	0.109	0.079	28
D 31	6.27	1.00	0.045	0.111	28–29
D 32	5.12	1.00	0.055	0.075	28+
D 33	5.31	1.00	0.050	0.046	29
D 34	4.75	1.00	0.075	0.059	30

Table I—Molecular Formulae of Clays—Concluded.

Sample Number.	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	Fusion Point.
D 35	4.32	1.00	0.050	0.072	28
D 36	5.56	1.00	0.062	0.070	22
D 44	5.89	1.00	0.038	0.062	30
D 45	4.77	1.00	0.087	0.055	22
D 46	3.81	1.00	0.070	0.054	29
D 50	5.77	1.00	0.135	0.032	26
D 56	3.72	1.00	0.019	0.007	Not reached
V 4	3.16	1.00	0.037	0.036	Not reached
V 5	3.51	1.00	0.073	0.050	Began to bend at 30
V 11	3.59	1.00	0.079	0.061	Not reached
F 6	5.28	1.00	0.047	0.078	30
F 16	4.05	1.00	0.053	0.060	30
F 18	5.19	1.00	0.065	0.069	29-30
F 19	5.77	1.00	0.056	0.074	30+Not fused down
R 1	2.504	1.00	0.014	0.060	34+
R 2	2.645	1.00	0.015	0.074	34+
R 3	5.44	1.00	0.023	0.079	27
R 4	4.90	1.00	0.044	With Al_2O_3	27
R 5	1.99	1.00	Trace	With Al_2O_3	34+
R 6	5.97	1.00	0.019	0.126	30
R 7	1.68	1.00	0.051	With Al_2O_3	29

Determination of Fusion Point.—A preliminary fusion test was made on all clays sent to the laboratory in order to determine whether or not they had a refractory value sufficiently high to warrant a more careful test at a higher heat. By this process of elimination a majority of the clays tested were excluded from the fire clay or refractory class. All clays that withstood without deformation a heat treatment sufficient to melt down Seger cone 22 were re-tested.

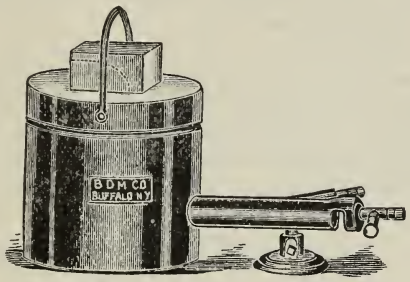

FIG. 2. Gas furnace used in testing clays.

An ordinary gas furnace, as shown in figure 2, was used in the fusion test, and artificial gas with compressed air supplied the heat. With this furnace and fuel, cone 32 was melted down in three to four hours.

Under these conditions a reducing, neutral or oxidizing flame was produced at will by altering the proportions of gas and air. This ability to change the character of the flame was found to be very advantageous in determining the behavior of the clays under varying conditions. If the clays had contained only a trace of iron the character of the flame would probably not have been a matter of much consequence, but there was a relatively high percentage of iron, as shown by the analyses, and in several instances the behavior of the clay differed notably according to the character of the flame.

In the preparation of test pieces a portion of each sample was first crushed in a jar crusher and then quartered down until there remained about 150-200 grams, which amount was then ground in a porcelain mortar until it would pass through a 40-mesh sieve.

From this six cones* of the size and shap of the Orton-Seger cones were prepared and stamped with the sample number of the clay. When these cones were dry the base of each cone was pinched off, leaving only about two-thirds of its original height. The Orton-Seger cones were broken in a similar manner.

* The steel mold in which the clay cones were made was kindly furnished by Professor Edward Orton, Jr.

In the preliminary test burn, one cone each of three different clays, and, in the final burns, three cones of a single clay, were placed in the center of a circular plaque, as shown in figure 3.

Around the outer edge of the plaque were two sets of cones covering a range of at least eight cones. Each set of standard cones was placed, as indicated in figure 2, on either half of the plaque, so as to make easy the detection of inaccurate results due to irregularity of heat distribution. When the clay cone bent over sufficiently to touch the plaque, it was said to be fused.

Range from vitrification to fusion.—It was the desire to obtain definite data on the heat range of each clay from vitrification to fusion, since this property of a clay is considered of vital importance in a great many cases; as, for instance, where the fire clay is to be subjected to the disintegrating influence of vapors. In this investigation there was only partial success, as will be noted later.

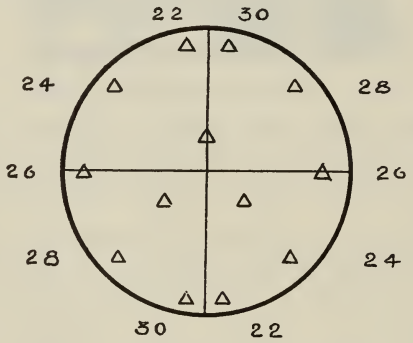

FIG. 3. Arrangement of cones on plaque.

The degree of vitrification obtained at several heats was ascertained only by an examination of the fracture of a broken cone or by the appearance of its surface.

Fineness of grain.— A very crude and unsatisfactory method of determination of the fineness of grain was adopted, but for lack of time it was the only method that could be employed. One hundred grams of each clay were taken from the jaw crusher stock, air dried, placed in a mason jar, covered with distilled water, and thoroughly shaken by hand until all the material was in suspension. The jars were then set aside for forty-eight hours, shaken thoroughly again, and the contents washed out into a battery composed of sieves having 20, 60, 100, 150, and 200 meshes. The residue on each successive sieve was washed by a water jet under pressure, until the water passing through was comparatively clear. In no instance was mechanical force used in the separation. The residue left on each sieve and an aloquot part of the slip that passed through the 200-mesh sieve was evaporated to dryness and the residue calcined and weighed.

Slacking—Believing that it is important to know the comparative rate with which the fire clays slack in water and develop their maximum fineness of texture, the material in the mason jars was examined

by rubbing the paste between the fingers and thus noting the degree to which the lumps had disintegrated. All the clays thus examined seemed to be completely slacked in forty-eight hours. From this it is to be inferred that all these clays slack readily.

Plasticity.—A portion of the forty-mesh stock of each clay was wedged on a plaster slab until it developed its maximum plasticity. This portion was then tested against the following arbitrarily chosen standards by noting the relative plasticity, and it was graded as A, B, C or D, according to the standard most closely resembled.*

A. Tennessee bal lclay No. 3.
B. Four parts of Tennessee ball clay and one part of flint.
C. Two parts of Tennessee ball clay and three parts of flint.
D. One part of Tennessee ball clay and four parts of flint.

Drying and burning.—A few of the clays were made into brickettes by the stiff mud process, dried in the sun, and when dry were burned in a down draft kiln exposed to the full play of the flames. In the burning test a temperature of 1120°C, as measured by a Le Chetelier pyrometer, was attained in twenty-four hours of continuous firing under oxidizing conditions.

Interpretation of Results.

While the degree of accuracy of the data here presented is considered by the writers to be within the limits of error of the several determinations, there is, owing to the lack of analogous scientific data, hesitancy in attempting an interpretation of their bearing on the possible utility of the clays. This will be made plain when it is considered that the factors affecting the heat of fusion of such complex and unknown mixtures of minerals and compounds as clays are known to be are little understood. While there are some accurate data available on the pyro-chemical behavior of a few of the "simple" mixtures of minerals and oxides that are known to be generally present in clays, there are no accurate data, emperical or scientific, known to the writers on the pyro-chemical behavior of a "complex" mixture of these minerals and compounds. The lack of agreement in the fusing point is strikingly shown in Figure 4, where the Seger Al_2O_3-SiO_2 and kaolin-SiO_2 fusibility curves are plotted together with the relative positions of the fire clays tested in this investigation. It is believed that this lack of conformity of the fusion points of these fire clays to the laws governing the fusion of simple mixtures, as shown in the figure, is not due to inaccuracy or error, but rather to the physical properties peculiar to the individual clays. Similar results are reached by plotting the corresponding fusion points of a group of New Jersey clays, as shown in the same plate.

It will be noted, therefore, that in very few instances is any statement made as to the possible uses to which the tested clays would be adapted. This reluctancy is founded wholly upon the lack of sufficient evidence on the pyro-chemical behavior of the clays. The

* This method was devised and the test executed by J. F. Krehbiel.

ultimate fusion point, chemical composition, and fineness of grain all have their bearing upon the working properties of the clays, but the most vital property is rate of vitrification. It will be noted that in the case of samples D 28-31, inclusive, and again in the case of F 6, F 16, F 17, F 18 and F 19 the clays have relatively high refractoriness,

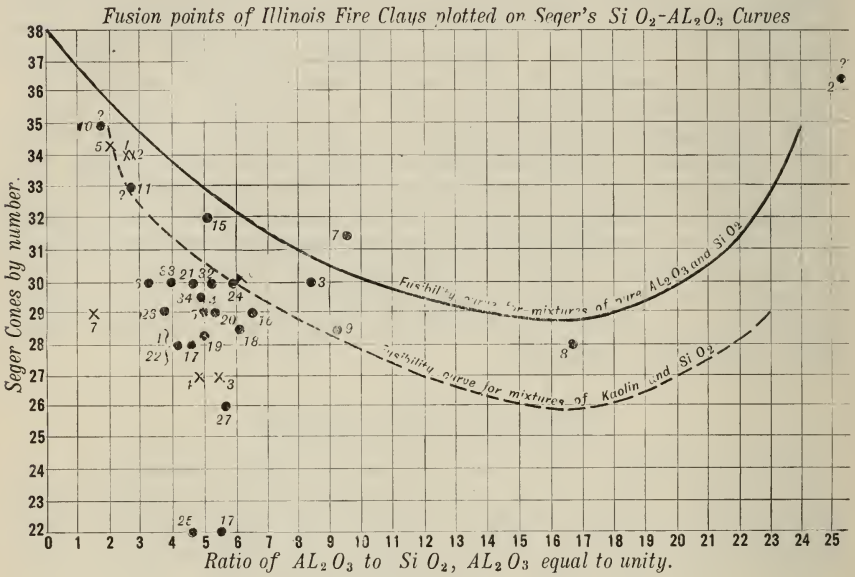

Fig. 4. Fusion points of clays and artificial mixtures.

and so far as their actual fusion point is concerned should be classed as very good refractory material. These clays are excellent stoneware clays because they are plastic, fine grained and burn to a clean buff color; but the one property that makes them peculiarly adapted to stoneware manufacture is their early vitrification followed by an extremely slow rate of fusion. At cone 7 or 8 they have acquired a density of structure that makes them so nearly impervious to oils and liquids that they can be practically considered as vitrified at this heat. While this early vitrification is very desirable in stoneware, it is decidedly disadvantageous, if not detrimental, to fire brick which are supposed to withstand sudden changes in temperature.

On the basis of this early vitrification of some fire clays, clay workers are accustomed to classify the fire clays into groups No. 1 and No. 2. The No. 2 fire clays vitrify at comparatively low heat treatment (cones 7 to 10), but do not necessarily fuse at a correspondingly low heat. In fact, very little has heretofore been known, or at least published, concerning the actual fusion point of the No. 2 fire clays. The No. 1 fire clays of the clay workers' classification, on the other hand, are those clays that do not vitrify at a low heat, but remain "open and porous" up to temperatures exceeding the normal heats (cone 11 or more) attained in the clay worker's kilns. Many data are available on the ultimate fusion points of the No. 1 clays, especially

those used in the fire brick manufacture, and yet the fact that their fusion point, in the majority of cases, does not exceed that of the so-called No. 2 fire clays is not generally known. In fact, but very little note has been taken by investigators and writers of the possible coincidence of the fusion points of these two classes of fire clays.

It must be borne in mind that not all the No. 2 fire clays have a refractoriness equal to that of the No. 1 clays. There are a great many No. 2 fire clays which exhibit a comparatively rapid rate of vitrification and fuse at heats ranging from cone 16 to 26; while No. 1 fire clays do not fuse at a heat treatment lower than cone 26.

Consciously or unconsciously, experimentors have used this difference in point of fusion between No. 1. and No. 2 fire brick clays as a basis of a classification into "refractroy" and "non-refractory" fire clays, the refractory clays having a minimum fusion point of cone 26 or above. A fusion point of cone 26, in other words, is the point of distinction between the non-refractory and refractory fire clays.

Based upon the tests made by the survey this classification is the only one that can be adopted, although it is realized that for properly judging of the commercial uses of the fire clays the clay worker classification into groups No. 1 and No. 2 would be far more expressive. But as this would necessitate a careful study of the rate of vitrification of the clays, and the time available did not make such a study possible, definite statements as to the commercial use of the fire clays cannot be made at this time. Such suggestions of "possible" uses as seem warranted by the evidence are included with the notes on the individual clays.

Geological Distribution of Fire Clays.

The proximate distribution through the State of the clays examined up to this time for refractory and also for paving purposes is shown on Plate 3, together with the distribution of the geologic series. It will be noticed that the clays of "refractory" and "less refractory" quality occur in three different geologic series, which, in order of formation, are the Mississippian, Coal Measures and Tertiary. The clays of the first group, however, in two cases at least are of doubtful origin and probably were formed by processes operating since Mississippian time, as will be explained later. The Tertiary region of the map, moreover, includes also probably Cretaceous strata. The discussion of the clays investigated, however, may well follow an outline based on geologic origin. These will be discussed in the following order: (1) Clays of Cretaceous-Tertiary age; (2) Clays of Coal Measures age; (3) Clays of Miscellaneous origin and age.

Fire Clays of Cretaceous-Tertiary Age.

Though the value of these clays for pottery was early recognized and small plants were established at Pulaski and Grand Chain landing, in Pulaski county, the only clays at present utilized occur in Massac county, near Round Knob. Clay is shipped from this point by rail to

Paducah, Kentucky, and by wagon for use at the two potteries located at Metropolis. The accompanying map (Plate 3) representes the general localities where samples were collected and where clays of highest value were found.

GEOLOGICAL RELATIONS.

Distribution and Character.

The Tertiary-Cretaceous area presents a mild topography which contrasts strongly with that of the deeply eroded district closely adjoining. There are two main types of surface features, alluvial flood plain and gently rolling upland. The former type is prominently developed in all of these counties, especially in Alexander, where from Cairo it extends north nine miles and northwest about fifteen miles to Santa Fé and Olive Branch. Its surface is essentially flat and regular, though locally broken by lines of recent erosion or irregular swampy areas. There is a marked northward extension of the Mississippi-Ohio bottoms along Cache creek to the swamps in northern Pulaski and Massac counties, and from there along Big Bay creek through Pope county to the Ohio river. This line of lowland probably marks the path of the Ohio river at an earlier stage of development. The flood plain is also well developed between Metropolis and Brooklyn, and again between the latter place and New Liberty, occupying the bend of the river.

The elevation* of the flood plain varies from about 320 to 350 feet above sea level, while low water of the Ohio river is 268 at Cairo, 280 at Yates Landing and 285 at Metropolis.

The upland of this district lies mostly east of the Cache river and south of the swamps already mentioned. There is some evidence that it was formerly developed to the north a few miles beyond Vienna, in Johnson county, and also beyond the Bay bottoms near Tansill, in Pope county. Where extensive this upland area is characterized by gently sloping or even nearly flat surfaces. It is, however, in process of erosion by surface agencies and is locally rather deeply channeled and gullied. While most of the upland lies below an altitude of 500 feet, many of the hills reach just about to this level, suggesting a former wide extent at this elevation. Along the Pope-Massac county line a few wooded hills attain a height of 575 feet or more.

The clay of this region is notably light in color, usually white or cream, but varies to buff, brown, chocolate and slate color. In rare instances it assumes a pink or vermillion hue of striking appearance. It is usually a "fat" compact earth of fine grain and smooth texture, which on addition of water becomes exceedingly plastic. It is bedded, however, and varies irregularly or by beds and being in places more open and "lean" where a very fine micaceous sand of light gray color is present. The interbedded layers of clay and sand vary in thickness from small fractions of an inch to several feet, as will be shown later

* Elevations in this work were based on the topographic map of Illinois, prepared in 1893 by Professor C. W. Rolfe.

in the field descriptions of clays sampled. Immediately above the fire clay there is usually a conspicuous band of brick-red clay and sand, measuring as a rule from one to three feet in thickness, and itself overlain by a thin bed of chert gravel. The pebbles in this gravel are an inch or less in diameter, smoothly rounded and coated with a thin film of iron oxide, which imparts a brown or bronze color. Occasionally the pebbles are locally cemented by iron into a firm conglomerate, half a foot or more in thickness.

The outcrop of the gray fire clay or its ascociated red clay and gravel is found in all the counties shown in Plate 3 as covered by Tertiary deposits, and also in Johnson county. While it is rarely seen in the flood plain district, except where deep ditching or stream cutting has removed the alluvial deposit, it is a conspicuous feature of the uplands. Here white or red clays are seen in ditches along the highways or lanes or on the hillside fields are revealed by local gullies. Indeed, the presence of the clays is often indicated by extreme "wash" or gullying of hillside slopes, though careful search may be necessary before the outcrop is found. This associated topography is doubtless due to the fact that rain sinks down into the surface "loess" or loam of the hills until the impervious fire clay checks the descent and causes the water to ooze from the hillside in a line of springs at the clay horizon. This concentration of erosion at the base of the unconsolidated surface covering causes rapid and conspicuous gullying.

In Alexander county the best exposure of fire clay occurs at Santa Fé, in the ravine occupied by the Miami Powder Company.

In Pulaski county it is seen at many places, and the best localities are: (1) Along Cache river and one mile east of Unity; (2) at Pulaski, in the hill east of town; (3) north of Grand Chain, in sections 20 and 21, town 14 south, range 2 east; (4) in the bluffs of the Ohio river, between Olmstead and Yates Landing.

Massac county offers perhaps the most numerous outcrops of the fire clay or the red clay and gravel which seem to accompany it. The most conspicuous occurrences noted, passing from west to east, are the following:

T. 15 S., R. 3 E., Sec. 5. (Middle.)
T. 15 S., R. 3 E., Sec. 13. (S. E. ¼.)
T. 14 S., R. 3 E., Sec. 27. (N. E. ¼.)
T. 14 S., R. 4 E., Sec. 9. (¼ mile east of Columbia.)
T. 15 S., R. 4 E., Sec. 17. (⅛ mile west of Forktown.)
T. 15 S., R. 4 E., Sec. 21. (N. E. ¼.)
T. 15 S., R. 4 E., Sec. 10. (Govert farm.)
T. 15 S., R. 4 E., Secs. 1 and 2. (South of Round Knob.)
T. 14 S., R. 5 E., Sec. 19. (S. W. ¼.)
T. 14 S., R. 5 E., Sec. 31. (S. W. ¼.)
T. 14 S., R. 5 E., Sec. 33. (E. ½.)
T. 15 S., R. 5 E., Sec. 4. (S. E. ¼.)
T. 15 S., R. 5 E., Sec. 21. (E. ½.)
T. 15 S., R. 5 E., Sec. 22. (W. ½.)
T. 15 S., R. 5 E., Sec. 25. (E. ½.)
T. 15 S., R. 6 E., Sec. 5. (N. E. ¼.)
T. 15 S., R. 6 E., Sec. 3. (N. ½.)
T. 15 S., R. 6 E., Sec. 34. (N. E. ¼.)
T. 16 S., R. 6 E., Sec. 12. (E. ½.)

Near Round Knob at the above location there are two clay beds forty-five feet apart. In Pope county only four observed occurrences of the Tertiary-Cretaceous fire clay are worth note. These follow:

T. 14 S., R. 5 E., Sec. 24. (On Robinett Creek.)
T. 14 S., R. 6 E., Sec. 11. (N. W. ¼.)
T. 15 S., R. 6 E., Sec. 25. (N. W. ¼.)
T. 16 S., R. 7 E., Sec. 9. (½ mile west of Hamletsburg.)

In Johnson county clays were observed near New Burnside in T. 11 S., R. 4 E., section 4; and near Vienna in T. 13 S., R. 3 E., section 4. These are assigned with some hesitancy to the same class as the clays already described. In the absence of detailed topographic maps it was impossible in this work to ascertain the exact elevations of the various clay outcrops. On the basis of barometric determinations, however, it appears that the beds observed in the vicinity of Round Knob, Massac county, rise towards the north about twenty feet per mile.

Geology of the Region.

A discussion of the probable extent, thickness and character of the clays found in the Tertiary-Cretaceous area should depend on a knowledge of their origin and so of the regional geology. This investigation, however, was limited to a hasty examination of local phenomena and served to show that a thorough knowledge of the geology can be obtained only by extending the field study to the area adjoining on the south. This is true because in much of the Illinois area the critical strata are thoroughly concealed by a thick deposit of alluvium and upland loess; exposures of more than a dozen feet or strata are rare and well records of value are obtainable only at widely scattered localities. Those interested in the geology of the region should avail themselves of the recent publication of the U. S. Geological Survey,* which discusses the matter and also gives a bibliography covering the most important papers heretofore published in this region. On account of its limited scope the present paper can only summarize the knowledge gained by other observers, working over a wider territory and supplement it with the additional notes of this investigation.

In respect to topography and geology this area is a part of the so-called "Gulf Embayment," which extends with varying width along the valley of the Mississippi from its mouth to southern Illinois. Lying on a floor of older Paleozoic rocks, the embayment deposits of Cretaceous and Tertiary age attain in the deep portion of the basin a thickness probably exceeding 2,000 feet, which diminishes towards the borders of the area to a feather's edge. The extent of the upper beds exceeds that of the lower, suggesting the maximum submergence of the valley towards the close of the era. The great accumulation of more or less unconsolidated beds has in the course of study been divided into several formations. Those occurring in southern Illinois are included in the following table:

*Water Supply and Irrigation Paper No. 164.

System.	Series.	Formations.
Quaternary	Pleistocene and recent	Alluvium Loess
Tertiary	Pliocene	LaFayette
	Eocene	Lagrange Porters Creek
Cretaceous		Ripley
Paleozoic.		

PALEOZOIC FORMATIONS.

Paleozoic rocks form the floor upon which the embayment deposits were laid down and border the area approximately as shown in Plate 3. Along most of the contact these older rocks are of Mississippian age, but in Alexander county, Devonian, Silurian and Ordovician formations are exposed. They are predominently of sandstone and limestone, with lesser amounts of shale, and presumably furnished by decay considerable of the material which finally came to rest beneath the waters of the embayment.

CRETACEOUS SYSTEM.

Ripley formation.—In the most recent publication on this area* the Ripley formation of Cretaceous age is said to cover the embayment area of Pope and Massac counties, probably the north half of Pulaski county, and to extend as a thin belt along the north border of the embayments in Alexander county to Santa Fé. Much of this region has been regarded heretofore as covered by the Tertiary deposits of Eocene age, and the evidence for correlation with the Ripley does not seem conclusive as yet, though the field observations favor this view. The question can presumably be settled by a study of the fossil leaves which frequently occur bedded in the clays of the formation. The Ripley is composed of a succession of fine clays and sands, with occasional layers of gravel. Outcrops do not reveal the full thickness of the formation in this region, though its present thickness, as interpreted from well borings, is said to be 200 feet at Paducah and only twenty-five feet at Mound City and Cairo.†

As most of the clays sampled in this area belong presumably to the Ripley formation, some notion of the detailed stratigraphy may be gained from the notes which follow at a latter place in this report.

TERTIARY SYSTEM.

Porters Creek formation.—A single outcrop here is correlated with the Porters creek of the Eocene, on the basis of similarity and probable continuity with beds exposed further south. At Caledonia Landing, east of Olmstead, it rises fifty feet or more from low water level and is composed of shale, as indicated by the following measured section. On the evidence of the greenish sand present. these strata are presumed to be near the base of the formation.

*L. C. Glenn, Underground Waters of Tenn. and Ky., etc., U. S. Geol. Surv., Water Supply Irr. Pap. 164. p. 27.
†Op. cit., p. 148.

Sections at Caledonia Landing.—

	Feet.
Gravel, sand and shale fragments	5
Shale fragments; light gray; probably "in place"	25
Shale; light gray, lumpy	11
Sandy clay; greenish gray and seamed by ferruginous clay "dike"	1
Clay shale; dark gray or drab; seamed by ferruginous clay "dike"	6
Shale fragments; light gray	3
Clay shale; brown to black; "fat," lumpy	3
Shale debris; dark and light gray	2

Water level 275 A. T. (Barometer.)

In the wells above referred to at Cairo and Mound City the eroded beds classified as Porter's Creek are 100 feet thick. Where complete the formation is 175 feet thick.

LaGrange formation.—The later formations conceal the LaGrange in the southern portions of Alexander and Pulaski counties, where its presence is rendered probable by the outcrops a short distance south in Kentucky. Over the most of the Illinois area it is lacking; unless, indeed, it has been included by mistake with the Ripley foramtion. At Santa Fé, however, there is an outcrop of clays and sands which may tentatively be regarded as LaGrange. This locality offers partial exposures of gray and white clay shale interbedded with fine white micaceous sand. The top lies at about 500 feet A. T. and the base at 385 feet, in the ravine now occupied by the Miami Powder Company. There is a strong southward dip here which may well reduce the actual thickness of the exposed strata to about 100 feet. This outcrop, as judged by the lithology, represents either LaGrange or Ripley, and it is presumed to be the former on account of its much greater altitude than the Porter's Creek outcrop which lies east, and a few miles north.

A further indication of the age of the Santa Fé beds is derived from the presence of a 3-foot bed of hard sandstone interbedded with the clays about 35 feet above the base of the exposure. A similar bed of quartzite is reported* to occur just across the Mississippi at Commerce, Mo., where it is both over and under a clay and rises rapidly to the north. This latter bed is said to be traceable to the south over a wide area and to occur in close association with the Porter's Creek, since bowlders of the quartzite frequently lie upon beds of the latter age

La Fayette formation.—The sands and gravels of the La Fayette formation of the Pliocene occur conspicuously over all of the areas except where it has been removed from the dissected uplands and the alluvial flats by erosion. Over the upland hills it extends as a thin cap, itself overlaid by the loess. The highest outcrop observed was at about 600 A. T. in Sec. 31, T. 14 S., R. 5 E., east of Round Knob about two miles. The formation is composed of sand both fine and coarse, and beds of gravel which locally are upwards of 15 feet thick. The pebbles are of well rounded chert and measure mostly less than an inch in diameter and rarely more than two inches. They are coated by a film of iron oxide which imparts a red or brown color. The formation occasionally contains beds which are indurated; thus the gravels may be cemented into a solid conglomerate bed and the sands

*Personal letter of A. F. Crider, Director of Miss. Geol. Surv., 1906.

may be "case hardened" to a high degree. The base of the La Fayette is usually marked by a zone of red, plastic, sandy clay and pebbles, contrasting strongly with the gray or white beds of the older deposits. Doubtless the red zone is caused by the concentration of iron charged water above the beds of impervious clay. At other places the sands grade imperceptibly into those underlying the formation. In a few cases the sands are faintly bedded or cross bedded, though more often structureless.

An unusual thickness of the La Fayette is observed above the described section at Santa Fé, where it is composed of 65 feet of stratified gravel and sand of deep red and taffy yellow shades. The dip of the bedding planes is gently to the southeast. As otherwise observed the clearly defined La Fayette seldom exceeds thirty feet in thickness and is more commonly about twenty feet.

QUATERNARY SYSTEM.

Loess formation.—The loess lies as a mantle of fine clay or silt over the embayment deposits and laps beyond its borders over the Paleozoic formations. It is everywhere present except where removed by erosion. In composition it is a fine sandy clay rarely containing scattered or banded quartz pebbles the size of a pea. The prevailing color is yellow-brown, but tints of red or pink are not uncommon. Detailed measurements of thickness were rarely made in the course of this investigation, but the loess seems to average about twenty-five feet in thickness over much of this region, and perhaps to reach forty-five feet in extreme cases, along the river bluffs. These figures may represent accidental conditions only, since the loess of the embayment area is known to vary elsewhere from zero to over 100 feet.

Alluvial deposits.—The latest deposits of this region are the river flood-plains, whose great extent has already been described. There are two distinct flood-plains though not always present at one locality. The upper or "second bottoms" lies 45 feet or more above low water, and has a much greater extent than the lower plain, more recently developed at a level about twenty feet above low water. The lower flat is subject to partial or complete overflow at the present time, while the upper is for the most part, at least, above high water.

The composition of these alluvial deposits is commonly revealed along river bluffs and in water wells. Sandy clay predominates, but this gives way, on the one hand, to fine gray or blue clay or nearly normal loess, while on the other to beds of gravel one foot or more thick and composed of flint and sandstone pebbles commonly as much as two inches in diameter. Vegetal remains, leaves, and wood are often interbedded with the silts while other clays are darkly colored with organic matter.

The thickness of the alluvium can be obtained only from well borings, and as these rarely descend more than a few feet to water, it is

not possible to learn the thickness at many places in this area. At lower places along the Mississippi it is thought to be between 100 and 200 feet thick.*

Structure of the Embayment Deposits.

As revealed by the occasional exposure the beds of this region are nearly horizontal but dip to the south about 20 feet per mile. Rarely, however, do the outcrops offer data of value for a determination of dip. At Santa Fé the dip is southeast, near Round Knob it is southwest. The broader study of the embayment area as a whole, however, has seemed to show dips toward the longitudinal axis of the region, and the condition has been illustrated by showing the resemblance to a great spoon, open side up, and with the tip end in southern Illinois. This attitude of the beds is thought to reflect the general position of the Paleozoic flow upon which the later sediments were deposited.

Geological History of the Embayment Area.

From the foregoing descriptions of the stratigraphy and structure of the Illinois embayment area it is possible to deduce the principal events in its history. During the early part of the Cretaceous period the gulf waters extended northward an unknown distance, probably reaching nearly to Kentucky. At the close of the period they extended over all of the Illinois embayment, to the Paleozoic rim as we know it now, and perhaps sent arms into the deep valley further north in Johnson and Pope counties. This distribution is indicated by the extent of the various Cretaceous sediments, which were brought to the embayment and there deposited in various relations, dependent on the balance between load and transportation power of the water. The rapid change in lithologic character of the beds both horizontally and vertically indicate the prevalence of local variations in strength of current or character and amount of detritus. The sediments were, however, notable fine and free from gravel as though erosion in the adjoining Paleozoic area was proceeding slowly and the transporting power of the streams and embayment currents, on the whole, was slight. In the Illinois portion of the embayment the waters of this period were presumably fresh or brackish, although marine conditions prevailed in Tennessee and further south.

Some time after the deposition of the Ripley formation the embayment waters receded from Illinois and the newly deposited beds became subject to the erosion. This is indicated by the irregular thickness of the Ripley formation in well borings and in part by the visible unconformity in some portions of the embayment area. Thus while at Paducah, Ky., the Ripley is thought to be 204 feet thick, it appears to be only 25 feet thick at Cairo and Mound City.

With the deposition of the Porter's Creek beds began a new period of embayment conditions. Certain green sands and marine fossils near the base of the formation indicate the presence of the sea, prob-

*U. S. Surv. Water Sup. Irr. Pap. 164, p. 49.

ably as far north as Caledonia Landing. Since the remainder of the formation, however, is free from such beds it is presumed that the clays and fine sands composing it were deposited under fresh or brackish water conditions by currents of varying strength but in the main relatively weak.

The LaGrange deposition probably extended over all of the Illinois embayment area, though this is a matter of doubt. It seems at least to have reached Santa Fé, and may possibly have reached north into Jackson and Pope counties. The conditions of deposition appear to have been much as during the previous epoch, but as sand predominates over clay and as cross bedding is conspicuously present in exposed strata, it is presumed that currents were stronger and perhaps more variable.

After the LaGrange epoch and before the deposition of the La Fayette formation an extensive erosion interval occurred. This removed much of the Ripley formation from the Illinois embayment, and also of the LaGrange, if indeed it previously had an extensive presence. The La Fayette lies everywhere unconformably over the older formations.

Extent, Thickness and Character of the Clays.

The probable extent, thickness and quality of the clays is seen to depend on the conditions under which they originated. It is believed that they are of secondary nature as contrasted with others sometimes formed from decomposition of older rocks "in situ." The source of the clay material was doubtless the older Paleozoic area which surrounds the embayment. The rocks of that area are highly argilaceous and siliceous, and a large quantity of clay making material is contined in the exposed limestone of the area. The resultant products of sub-aerial weathering, including solution, were carried by the Cretaceous and Tertiary streams to the embayment waters which were at various times saline, brackish and fresh. There, as today, under similar conditions, the coarser and heavier detritus was the first to sink to the bottom of the bay, while the finer portion was carried on by the currents and allowed to settle in those places where the waters are for various reasons quiet. As the strength of the currents doubtless varied from time to time as did also the character of the sediment contributed by the streams, certain areas of the embayment bottom received alternating deposits of the agilaceous clay and coarser sand in proportions everywhere different.

It appears, therefore, that the clays investigated represent a development which is highly characteristic of the whole gulf embayment area; the formations containing the clays are extensive. Particular clays, however, occur in more or less local development, carying in horizontal and vertical extent and "fingering" irregularly into the neighboring sediments. In general it may be considered probable that the thicker clay "lenses" are also often greater areal extent.

Commercial Development.

The further development of these clays seems to depend on two generally recognized factors; viz.: The quantity available for transportation and the uses for which they are suited.

The present hasty field examination has shown that there is probably a great quantity of these clays within easy reach, and that in this respect the chief problem is to select locations offering if possible both easy stripping and ready transportation facilities. Prospecting any particular area should be easily accomplished. The clay can frequently be found cropping out along river bluffs, roadway gutters, or in creeks or surface gullies immediately underlying the basal red clay and gravels of the LaFayette formation. This association is of great value in search for outcrops. Since the clays are, within short distances, essentially horizontal, the probable level of an occurrence can be roughly determined instrumentally from known outcrops near at hand. The character and thickness of a clay is best determined by making a "facing" with pick and shovel. Auxilliary tests are easily made with a post hole auger, or a common wood auger, to which is attached an iron rod or gas pipe shafting in detachable sections. This method has already been used near Round Knob, where it gave satisfactory samples for preliminary laboratory tests. It is hardly necessary to state that any movement to open up the clays of this district should be based on a thorough knowledge of the deposits acquired by thorough and systematic prospecting and testing. A method sometimes used in such areas as this is to sink shafts with windlass and shovel. Such a hole should be as small as posible so as to reduce the chances of caving. Three feet in diameter is a common size used. With a sharp spade a man can thus sink a hole rapidly and obtain excellent samples for examination. Danger is best avoided by working in dry weather at the highest possible speed but curbing is sometimes necessary. In case of deep shafts air should be pumped to the bottom by means of a small fan such as is commonly attached to a hand forge.

The localities which at this time seem most promising are those offering most ready transportation, or stripping advantages. It would be especially desirable to locate near the rivers, if possible, so as to take advantage of cheap hydraulic methods of stripping. The exact locations from which samples were collected in this examination are recorded in the following field notes.

Field and Laboratory Notes on Cretaceous-Tertiary Clays.

Clays from near Round Knob, Massac County.

(Samples D 28, 29, 30, 31.)

FIELD NOTES.

These samples represent different portions of the clay now being mined for pottery near Round Knob, Massac county. It appears to be a horizontal bed of Ripley, or possible Lagrange, age, which occurs in much of the upland area here wherever the hills rise above its horizon. The clay is light gray and is overlain by reddish clay and gravel of the La Fayette formation which serves to mark the place of the under-

lying clay throughout this immediate district as elsewhere. Great quantities of the clay are available here for development and shipment on a large scale. It varies from a very fat variety to one in which fine white sand predominates. Doubtless the various grades here available can be mixed to bring out many different desirable qualities.

D 28. Potter's clay from S. W. ¼ Sec. 1; T. 15 S., R. 4 E. A small pit on the farm of George Grothman, a few rods east of the Ill. Cent. R. R., shows six feet of light gray clay overlain by about the same thickness of soil and clay stained with iron. The clay lies about 60 feet above the railroad in a small oval hill. The output of this pit is now hauled six miles to Metropolis, where it sells to the potters for about $1.50 per ton delivered. It makes a superior clay for molding and turning into stoneware, possessing qualities causing it to shrink evenly without cracking, to take a good glaze and to hold oils and liquids without seepage.

D 29. Potter's clay from N. ½ of S. W. ¼, Sec. 8 T. 15 S., R. 4 E., from pit of Ohio Pottery Company. This pit is located about one-half mile west of the Grothman farm and on the slope of a gentle hill. In general the working face shows 14 feet of loess, sandy clay and ferruginous material overlying about 10½ feet of interbedded plastic clay and gray or yellow sand. A detailed section at the highest part of the outcrop is as follows:

Section near Round Knob.

Stripping—	Feet.	Inches
Loess	6	
Clay and ferruginous sandstone, all stained deep red	1	
Sandy clay with few standstone concretions	7	
Commercial portion—		
Sandy clay; thinly laminated; drab	1	11
Fine sand; thinly laminated in brown, yellow and white streaks	1	4
Clay, brown to gray; stopped and banded with gray sand ¼ inch thick	1	10
Sand white and yellow streaks becoming red at bottom	1	2
Clay and sand interbedded, gray and drab		4½
Sand; thinly laminated; gray	1	2
Clay; gray to brown; fat	1	
Sand; fine, fluffy, gray		7
Clay; dark gray and with few sand streaks		4
Sand; very ferruginous		¼
Clay; sandy, gray		11
	10	7¾

Of the commercial portion the colored layers found in the second and fourth strata are excluded from shipment. The same part was also excluded from sample. The planes in this pit are horizontal, but there is evidence of recent disturbance. The south wall shows a small thrust fault with a throw of 12 inches, and associated with it a vertical zone, 8 feet wide, from which the clay has been removed, and in which is deposited some of the reddish sandy clay which normally overlies the gray clay.

The output of this pit, reported to be about five cars weekly, is shipped by rail to Paducah, Ky., where it is made into stoneware.

D 30. Potter's clay from the same property and bed as D 29, but located a couple of hundred yards to the southwest. The abandoned pit shows an outcrop of 6 feet of clean, fat clay of light brownish gray color. The former working face presented 27 feet of this quality, according to the statement of the superintendent. It was shipped to Paducah for stoneware, but required the addition of other clays to make it usable. It would seem that other fine sandy clays from this same neighborhood could be added to gain the proper constituency.

D 31. Sandy clay from an abandoned pit located a few rods northwest of that from which sample D 29 was taken. This clay occupies a stratigraphic position just above the proceeding section.

Upper Section near Round Knob.

	Feet.	Inches.
Sandy clay	2	
Ferruginous plates		2
Clay; gray, but stained yellow and brown	1	9
Clay; gray and sandy	1	
Sandy clay; white	6	6
	11	5

The two lower strata were sampled for this test. The clay looks first class, but is reported by the manager to burn unsatisfactorily.

LABORATORY NOTES.

Mechanical Analyses.

Sample.	Moisture.	Volatile.	Residue Left on Screens.					Finer than 200 Mesh.	Total per cent.	Plasticity.
			20 Mesh	60 Mesh	100 Mesh	150 Mesh	200 Mesh			
D 28	2.46	4.78	0.260	0.217	0.324	0.664	0.426	89.270	98.40	C
D 29	1.88	4.96	0.163	0.306	0.818	1.754	1.294	82.977	94.152	B
D 30	4.02	7.20	0.445	0.346	0.666	0.956	0.643	72.947	97.223	A
D 31	1.42	4.90	0.053	0.158	0.804	1.238	0.949	88.321	97.843	A

Chemical Analyses.

Sample.	Moisture.	Volatile.	SiO_2	Fe_2O_3	Al_2O_3	TiO_2	Total per cent.
D 28	1.64	6.81	66.04	1.60	22.00	1.60	99.69
D 29	1.41	5.27	71.58	1.51	18.31	1.40	99.48
D 30	3.44	7.52	60.50	3.84	22.52	1.40	99.32
D 31	1.13	5.31	69.46	1.32	18.82	1.64	97.68

Pyrometric Tests.

D 28. This clay began to bend over at cone 26, but did not touch the plaque until after cone 32 was down. In preliminary test a sample gave evidence of incipient fusion at cone 20.

D 29. This sample began to fuse at cone 28. In preliminary test it was vitrified at cone 20.

D 30. The test piece started to bend at cone 23, and was touching the plaque at cone 28. In the preliminary test it was vitrified at cone 18.

D 31. At cone 28 this clay was almost touching the plaque. In preliminary test it was vitrified at cone 20.

Burning Tests.

The clays were molded into brickettes by the plastic or "stiff mud" process and burned in an open kiln at 1120°C, with the following results:

D 28. Porous buff brick.
D 29. Porous buff brick.
D 30. Vitrified nicely to a buff brittle brick.
D 31. Porous buff brick.

Summary.

These clays are high in silica but it is relatively fine, as shown by the large percentage of material that passed the 200-mesh sieve. The plasticity varies consideraly. On account of the high content of silica and the presence of a small per cent of alkalies and alkaline earths they doubtless lose some of their refractory qualities. Nevertheless on the basis of the pyrometric tests they all fall into the class of refractory clays. The low point and slow rate of vitrification is a leading characteristic.

The results of mixing these several clays cannot be predicted closely; but it would seem as though experiments along this line might be of value.

The preliminary experiments here recorded would seem to indicate the following possible uses for these clays:

D 28, 29, 30, 31. Stoneware, terra cotta, No. 2 fire brick and building brick.

D 28, 29. Refractory ware in which the low vitrification is not injurious.

(D) 30. Paving brick possibly, though perhaps too brittle at 1120° C.

(D) 28, 29, 31. Paving brick possibly, at a higher temperature than 1120° C.

Clays from Massac County.

(Sample D 32.)

FIELD NOTES.

Clay from Massac county, S. E. ¼, Sec. 33, T. 14 S., R. 5 E., along Massac creek on the farm of William Kortie. They clay sample repre-

sents four feet lying just above water level. It is overlain by 5 feet of clay, gravel and loess. A test hole sunk 3 feet below water level is reported to have found clay of the same quality as that exposed and sampled. This clay probably occurs in the Ripley formation at about the same horizon as the samples from Round Knob. It has an extensive development probably underlying the bottom lands along the creek in this vicinity and extending under the hills. Its location is unfavorable with reference to the present transportation facilities and possibly prohibits development.

LABORATORY NOTES.

Mechanical Analyses.

Moisture.	Volatile.	Residue Left on Screens.					Finer than 200 Mesh.	Total per cent.	Plasticity.
		20 Mesh	60 Mesh	100 Mesh	150 Mesh	200 Mesh			
2.94	6.32	0.021	0.723	5.598	5.762	1.806	74.568	95.738	D

Chemical Analyses.

Moisture.	Volatile.	SiO_2	Fe_2O_3	Al_2O_3	TiO_2	Total per cent.
2.58	6.83	64.88	1.86	21.54	1.26	98.95

Pyrometric Test.

This clay started to bend at cone 26 and at 28 it was touching the plaque. In preliminary test it was vitrified at cone 20.

Burning Test.

When molded into a brickette by the plastic or stiff process and burned in an open kiln at 1120° C it gave the following results:

Hard buff brick not far from vitrification.

Summary.

This clay on the basis of its pyrometric behavior lies close to the lower limit allowed for fire clays of the refractory grade. It would seem to be adapted, so far as these tests go, to the manufacture of a stoneware, terra cotta and No. 2 fire brick, and to have a possible use in making building and paving brick.

Clays from Pulaski County.
(Samples D 33 and D 36.)

FIELD NOTES.

D 33. Clay from Yates Landing, Pulaski county, Sec. 1, T. 15 S., R. 2 E. A cliff rising from the beach reveals at the base eight feet of gray micaceous clay. The bottom of the exposed bed lies 35 feet above low water. Below it the bank is strewn with masses of conglomerate. The clay is overlain with 17 feet of sandy clay, pebbles, and loess. The clay is probably of Ripley age, while the bowlders conglomerate may be La Fayette, but is probably of recent age.

This locality formerly furnished potter's clay which supplied a local plant. Raw clay was also shipped on the river. The possibilities of hydraulic stripping and easy transportation are exceptionally favorable.

D 36. Clay from Pulaski county, near Lockhart's Landing, Sec. 18, T. 15 S., R. 2 E. This occurs as an outcrop on the sloping beach, extending from near water up about 25 feet to the base of a 30-foot cliff of sand and gravel. The clay is mostly micaceous and sandy, varying in color from dark blue-gray or brown at the base to light gray or white at the top. It probably occurs in the Ripley formation near its upper limit.

A portion, and perhaps all of this horizon, is below the line of high water. It would, therefore, on this account be difficult to work the clay continuously. The high stripping is perhaps prohibitive to development at this locality unless hydraulic methods should be employed.

LABORATORY NOTES.

Mechanical Analyses.

Sample.	Moisture.	Volatile.	Residue Left on Screens.					Finer than 200 Mesh.	Total per cent.	Plasticity.
			20 Mesh	60 Mesh	100 Mesh	150 Mesh	200 Mesh			
D 33	2.90	4.58	0.069	0.183	0.896	3.094	2.088	81.53	95.34	A
D 36	2.46	4.78	0.260	0.217	0.324	0.664	0.426	89.27	98.401	C

Chemical Analyses.

Samples.	Moisture.	Volatile.	SiO_2	Fe_2O_3	Al_2O_3	TiO_2	Total per cent.
D 33.....	2.48	6.29	67.54	1.70	21.54	0.78	100.33
D 36.....	1.90	5.56	68.26	2.03	20.87	1.14	99.76

Pyrometric Tests.

D 33. This clay started to bend at cone 24, but was not quite touching the plaque at cone 28. In preliminary test it was vitrified at cone 20.

D 36. Both in preliminary and final test this clay was touching the plaque and badly blistered at cone 21.

Burning Tests.

When molded into brickettes by the plastic "stiff mud" process and burned at 1120° C in an open kiln these clays were hard, nearly vitrified and had a good buff color.

Summary.

These clays are high in silica and yet fine grained. They vary considerably in plasticity. The refractory value is low but the chemical analysis does not reveal the reason. In fusibility D 33 lies near the lower limit of refractory fire clays, while D 36 is well within the non-refractory class. They are possibly of value for the manufacture of stoneware, terra cotta and No. 2 fire brick and also for building and paving brick. It is reported in the field, however, that clay from D 33 while making excellent stoneware by turning is not suited for jiggering, because it sticks to the molds.

Clays from Pope County.

(Samples D 34, D 35.)

FIELD NOTES.

Clay from Pope county, Sec. 27, T. 14 S., R. 5 E., on the farm of C. Wolff along a branch of Robinett creek. It occurs in the slope of the hill above the creek with a covering of seven feet of loess and gravel. Five feet of clay is exposed and two feet more is reported to lie below it. As the creek is very small here, seven feet or more of clay is probably available for excavation if warranted. The bed is presumably of Ripley age, approximately the same as the Round Knob bed. Doubtless the hillside contains a great quantity, which can be obtained for very low expense for stripping; but as this place is fully five miles from the railroad and even further from the river only a clay of high grade can be profitably handled.

Samples were obtained by means of a post hole auger. D 34 represents the top three feet of the bed and D 35 the next two feet. Better knowledge of the working quality of the entire bed would have been obtained by combining the samples before testing.

LABORATORY NOTES.

Mechanical Analyses.

Sample.	Moisture.	Volatile.	Residue Left on Screens.					Finer than 200 Mesh	Total per cent.	Plasticity.
			20 Mesh	60 Mesh	100 Mesh	150 Mesh	200 Mesh			
D 34.....	4.54	6.16	0.086	0.118	0.502	2.042	1.210	81.147	95.80	B
D 35.....	4.78	6.66	0.142	0.161	0.753	1.765	1.176	.....	15.437	A

Chemical Analyses.

Sample.	Moisture.	Volatile.	SiO_2	Fe_2O_3	Al_2O_3	TiO_2	Total per cent.
D 34.....	3.36	7.04	63.20	2.50	22.60	1.04	99.74
D 35.....	3.88	7.20	61.20	1.89	24.11	1.36	99.64

Pyrometric Test.

D 34. This clay started to bend at cone 24, but did not touch the plaque until cone 30 was reached. In preliminary test it was vitrified at cone 20, but not melted to a globule.

Burning Tests.

These clays were molded into brickettes by the plastic "stiff mud" process and burned in an open kiln at 1120° C. Under this treatment they became hard, nearly vitrified, and exhibited a good clean buff color.

Summary.

These clays are comparatively fine grained, relatively high in fine silica and fairly plastic, i. e., plastic enough for fire brick purposes but perhaps not plastic enough for retort manufacture.

They contain but little flux other than iron and titanium. Their iron content is undoubtedly in a free or uncombined condition, which makes the clays of low refractory value in "reducing" fires. If they had been tested in a Deville furnace where excessive reducing conditions prevail, they would not have been reported as having as high a refractory value as here given. The discrepancy between the results of preliminary and final pyrometric tests gives evidence of the influence of the character of the fire gases. The plaque in the preliminary test was heavily reduced, and in a final test it was in an oxidized condition.

On the basis of pyrometric behavior under favorable conditions D 34 falls in the refractory fire clay class, while D 35 belongs more closely with those of non-refractory value. It seems possible that the clay of the combined samples may well be of value for fire brick or

for stoneware and terra cotta and building brick, though distance from transportation facilities would seem to prohibit its development at present.

Clays from Pulaski County.
(Sample D 44.)

FIELD NOTES.

Clay from Pulaski county, Sec. 31, T. 15 S., R. 1 W., on the farm of John Mansperger. The sample was taken from the material reported to have come from a bore hole on the floor plain of Cache river. The clay is reported to be ten feet thick and to extend from eight feet below the top of the broad flood plain down nearly to water level. The river bank shows just above low water, six feet of white silica, which is reported to underlie the clay. The clay is probably of Ripley age. On account of the location of this bed near the level of high water the conditions for continuous working are rather unfavorable. The creek however, furnishes sufficient water for use in hydraulic stripping, and the location is fairly convenient for shipment of clay by rail.

LABORATORY NOTES.

Mechanical Analyses.

Sample.	Moisture.	Volatile.	Residues Left on Screens.					Finer than 200 Mesh.	Total per cent.	Plasticity.
			20 Mesh	50 Mesh	100 Mesh	150 Mesh	200 Mesh			
D 44.....	1.56	5.82	0.813	0.216	0.385	1.644	1.045	87.247	98.73	B

Chemical Analyses.

Sample.	Moisture.	Volatile.	SiO_2	Fe_2O_3	Al_2O_3	TiO_2	Total.
D 44.....	1.11	6.35	69.92	1.21	20.19	0.98	99.76

Pyrometric Test.

D 44. This clay did not begin to bend over until cone 27 was reached, but was fused down at cone 30. In the preliminary test it was vitrified at cone 20.

Summary.

This is a comparatively fine grained clay, relatively high in silica, and with a fair amount of plasticity.

Its pyrometric value is equal to or better than that of many clays now used for fire brick purposes.

Clays from Pulaski, Pulaski County.
(Samples D 45 and D 46.)

FIELD NOTES.

Clay from Pulaski, Pulaski county, Sec. 15, T. 15 S., R. 1 W., on the land of J. L. Aldred. The occurrence is in the basal portion of a hill rising east of the town. The clay is interbedded with white sand, especially toward the bottom and is overlaid by a bed of gravel about ten feet thick, followed by loess. The clay probably belongs to the Ripley formation, and the elevation indicates that it is probably near the horizon of the clay last described. The samples represent fifteen feet of tolerably pure, fat clay, made easily available by the gentle slope of the hill, and situated within a short distance of the railroad. Samples of the clay are reported to have made good sizing of weighting for brown paper. It is reported also to be a good clay for stoneware. The following measured section indicates the nature of the deposit:

Section at Pulaski.

	Feet.	Inches.
Loess	15	
Clayey sand of red-brown color and containing gravels	9	
Clay; drab, gray and brown with some ferruginous streaks	10	
Sand; fine and white	1	
Bituminous clay	1	
Clay; drab; micaceous; interbedded with little white sand	5	
Sand and clay, predominately sand	6	
Clay; drab; fat	6	6
Sand, fine, white, micaceous	1	6

D 46 is composed of clay from the top half of the third stratum.

D 45 represents the lower half of the third and all of the sixth strata.

The outcrop offers possibilities of many mixtures, some of which might well give better results than the samples taken.

LABORATORY NOTES.

Mechanical Analyses.

Sample.	Moisure.	Volatile.	Residue Left on Screens.					Finer than 200 Mesh.	Total per cent.	Plasticity.
			20 Mesh	60 Mesh	100 Mesh	150 Mesh	200 Mesh			
D 45	4.58	6.16	1.268	0.827	0.411	1.744	1.294	83.28	99.57	A
D 46	4.34	11.18	0.591	0.470	0.295	0.654	0.885	83.852	102.26	A

Chemical Analyses.

Sample.	Moisture.	Volatile.	SiO_2	Fe_2O_3	Al_2O_3	TiO_2	Total per cent.
D 45	2.99	6.12	62.76	3.07	22.36	0.97	98.27
D 46	3.48	8.12	57.14	2.82	25.52	1.08	98.16

Pyrometric Tests.

D 45. The final test on this clay was very unsatisfactory; reducing conditions prevailed and the distribution of heat was unequal. Under these conditions cone 22 was fused no more than cone 25. The clay was bending and badly bloated. In the preliminary burn it was thoroughly vitrified at cone 18, and would have gone down at cone 20.

D 46. This clay started to bend at cone 24. At cone 29 it was not down but thoroughly fused and blistered. In the preliminary burn it gave evidence of incipient fusion at cone 18.

Burning Test.

Brickettes made from D 45 were so fine grained and plastic that they were dried with difficulty. Burning in the kiln produced incipient vitrification.

Summary.

These samples are high in free iron but contain only a little over one and a half per cent of other fluxes. They are as plastic as the Ball clay used as a standard in these tests. While a good test was not obtained on D 45, it may be safely assumed that it has not a refractory value sufficient to recommend it for a first class fire clay. It would seem, however, to be a paving brick possibility. D 46 falls below the refractoriness of the better fire bricks but may be of value for stoneware, terra cotta and No. 2 fire brick. It will be seen from the section given that these samples do not represent all the possibilities of these clays.

Clays from Massac County.

(Sample D 50.)

FIELD NOTES.

Clay from Massac county, Sec. 12, T. 16 S., R. 6 S., on the farm of John Ridenour. A bed two feet thick is exposed in the bottom of a small creek and two feet additional are shown below this by an augur hole. It is reported that the deposit exceeds eight feet in thickness and is fat and plastic and free from coarse sand. The sample represents the exposed clay.

The topography suggests that a considerable body of this clay is obtainable with small expense. The Ohio river is three miles distant.

LABORATORY NOTES.

Mechanical Analysis.

Sample.	Moisture.	Volatile.	Residue Left on Screens.					Finer than 200 Mesh.	Total per cent.	Plasticity.
			20 Mesh	60 Mesh	100 Mesh	150 Mesh	200 Mesh			
D 50.....	4.90	4.96	0.864	4.800	3.807	2.502	0.702	75.454	98.99	B

Chemical Analysis.

Sample.	Moisture.	Volatile.	SiO_2	Fe_2O_3	Al_2O_3	TiO_2	Total per cent.
D 50.....	3.55	6.02	63.32	4.09	19.25	0.48	98.71

Pyrometric Tests.

D 50. In the preliminary test this clay had fused to a globule at cone 16. From its appearance it was conjectured that the influence of the reducing fire had very materially lowered its fusion point, and it was suspected that in an oxidizing fire its fusion point would be very much higher. This conjecture was based on the fact that the way the cone bent over gave evidence of the presence of but very little active flux other than ferrous iron.

The correctness of this theory was proven by the second test in an oxidizing fire. It did not begin to bend until cone 22-24 was reached, and was not fused to a bead until cone 26 was reached. The character of the fire gases made a difference of 10 cones, or approximately 200 degrees centigrade in the pyrometric value of this clay.

Burning Test.

This clay burned into a hard tough brick, though far from vitrification at the kiln temperature.

Summary.

The relative fluxing effect of iron under reducing and oxidizing conditions is illustrated better with this sample than with any other tested in this work. The clay contains only one per cent of fluxes aside from iron; but since it is low in alumina and high in silica it may be said that the iron and silica act jointly in producing the flux.

Although of fair refractoriness under oxidizing conditions this clay would be very treacherous in places where reducing conditions might occur. Burning tests, however, warrant the assumption that the clay might be suitable for stoneware or paving brick.

Fire Clays of Coal Measures Age..

Plate 3 shows at a glance the approximate locations from which Coal Measures samples were collected, and also the distribution of such as proved to be "refractory" and "less refractory" grades. The greatest development of Illinois fire clays has taken place in this area. Of the establishments listed on a previous page all handle Coal Measures clays except that at Metropolis and, possibly, that at Drake.

GEOLOGIC RELATIONS.

Since the Coal Measures cover the greater part of Illinois, offering great variety in geology and topography the field relations of the fire clays are too diversified to permit of comprehensive examination and description in a preliminary investigation of this scope.

The presence of so-called fire clays is common throughout the Coal Measures area. They are shown in natural outcrops along river banks and ravines and in artificial exposures in mine shafts, water wells, highway or railroad cuts and other excavations. The clay presents a variety of colors and textures; it may be a homogeneous structureless mass or it may have the laminations of, and grade into, common shale. It may be fine, soft and plastic or relatively coarse, very hard and almost entirely non-plastic, approaching fine sandstone in appearance. Colors of fire clays are most frequently light gray, drab or buff, but browns and chocolate shades are not unknown. Weathered exposures rarely show the same shades as those which have not been exposed to the air.

The fire clay most frequently occurs beneath a coal bed although it may be associated with limestone, shale or standstone. In the absence of a coal the clay may not lie at a horizon which in adjoining areas is productive of coal. For these reasons the unwarranted assumption is commonly made that any clay lying immediately below a coal seam is refractory. Nevertheless, the most likely place to find a refractory clay in this region is beneath a coal and all of those sampled in this work occupy such a position. A knowledge of the geological and areal distribution of the various Illinois coals is therefore, of great value in a study of the fire clays.

The former Geological Survey divided the Coal Measures into two divisions the Lower or productive series and the Upper or non-productive series. Altogether the strata were estimated to be as much as 1200 feet thick and to contain at least sixteen distinct coal beds. Of this number nine were classified with the Lower Coal Measures. These include the coals now so largely mined in the State, and all of the Coal Measures fire clays tested by the survey. The areal extent of the Upper and Lower coal Measures in the State is approximately indicated on the large geological map recently published by the survey, and also on that accompanying the reports of the older survey. The former county reports contain notes on local geology which often include descriptions of the clays. Aside from these the only data available are the brief notes of the following pages.

The further commercial development of the Coal Measures fire clays is confidently expected. Further geological work should stimulate the production by tracing beds of known value into regions as yet undeveloped, and by demonstrating the presence of other good clays at present unrecognized. There is no reason for supposing refractory clays may not be discovered in the strata of the Upper Coal Measures. It is hardly necessary to say that the extent, thickness and quality of a clay at an given locality can only be determined by detailed prospecting and testing.

FIELD AND LABORATORY NOTES ON FIRE CLAYS OF THE COAL MEASURES.

Clays From Argillo Works, Carbon Cliff, Rock Island County. (Samples H 8, 9, 10.)

FIELD NOTES.

These samples were collected from an outcrop owned by the Argillo Works at Carbon Cliff, and located in detail as follows: NE¼ of SE¼, Sec. 5, T. 18 N., R. 1 E.

The exposed section of rocks is indicated by the following measurements.

Section at Argillo Works.

	Feet.
Shale; light colored and containing hard limestone fragments	12
Coal	1
Fire clay	3
Shale; black carbonaceous	1
Shale, ——— H. 8	1
Fire clay, ——— H. 9	12
Fire clay, ——— H. 10	+

Samples 8, 9 and 10 represent the three lowest strata.

LABORATORY NOTES.

Mechanical Analyses.

Sample.	Moisture.	Volatile.	Residue left on screens.					Passed 200 mesh.	Total per cent.	Plasticity.
			20 Mesh	60 Mesh	100 Mesh	150 Mesh	200 Mesh			
H 8	2.26	6.62	0.171	0.682	0.177	0.748	0.425	103.149	113.62	D
H 9	0.22	1.62	47.161	1.819	0.640	0.646	0.366	44.373	96.845	D
H 10	0.76	4.56	1.466	1.343	0.885	3.028	1.134	86.533	99.704	D

Chemical Analyses.

Sample.	Moisture.	Volatile.	SiO_2	Fe_2O_3	Al_2O_3	TiO_2	Total per cent.
H 8	1.81	6.66	61.46	2.19	24.05	1.60	97.77
H 9	0.16	1.68	91.18	0.55	6.05	0.80	100.42
H 10	0.60	4.63	76.10	1.10	15.31	1.31	99.05

Pyrometric Tests.

H 8. This clay began to bend at cone 24, and was touching the plaque at cone 28. In the preliminary burn it gave evidence of incipient fusion at cone 20 and was still standing erect.

H 9. This sample began to bend at cone 27, and was touching the plaque at cone 30. In preliminary burn it did not vitrify at cone 20.

H 10. Two of the cones made from this clay began to bend at cone 27 and were flat at cone 30, while the third one remained standing at 30, but was partly fused.

In the preliminary burn this clay was thoroughly vitrified at cone 20. In fact, it gave evidence of incipient fusion. In comparing the two tests, it would be inferred that the two cones which were down at cone 30 gave more nearly the pyrometric value of this clay.

Burning Tests.

Burning these clays in the form of brickettes at 1120° C gave the following results:

H 8. Bluestone buff.

H 9. A very coarse brittle mass.

H 10. Fine light buff; quite porous at this heat.

Summary.

H 8. This clay is very fine grained with low degree of plasticity. It contains 2.25% of fluxes other than iron and in fusion point lies near the lower limit for refractory clays. It might possibly be of use alone or in mixture for stoneware, terra cotta, No. 2 fire brick or paving brick.

H 9 and H 10. H. 9 and H 10 are relatively coarse grained and non-plastic. They contain but little flux other than iron and rank with the refractory clays. H 9 seems more favorable for fire brick manufacture and H 10 for stoneware or No. 2 fire brick.

CLAYS FROM WESTERN STONEWARE CO., MONMOUTH, WARREN COUNTY.

(Samples H 41, 42 and 43.)

FIELD NOTES.

These clays are obtained at the works of the Western Stoneware Company at Monmouth. The first and third are reported to come from Colchester, and the second from Tennessee, both nearby towns. The clays are mixed for the production of stoneware.

LABORATORY NOTES.

Mechanical Analyses.

Sample.	Moisture.	Volatile.	Residue left on screens.					Finer than 200 mesh.	Total per cent.	Plasticity.
			20 Mesh	60 Mesh	100 Mesh	150 Mesh	200 Mesh			
H 41.....	1.82	6.60	0.24	0.38	2.03	6.99	2.36	77.88	98.30	C
H 42.....	1.94	6.74	6.67	0.76	0.70	3.12	2.32	75.94	98.18	D
H 43.....	2.16	7.94	14.25	16.86	5.06	4.50	1.48	43.93	96.18	D

Chemical Analyses.

Sample.	Moisture.	Volatile.	SiO_2	Fe_2O_3	Al_2O_3	TiO_2	Total per cent.
H 41.....	1.25	7.05	66.50	1.56	21.50	1.28	99.14
H 42.....	1.62	7.37	65.14	1.59	21.53	1.60	98.85
H 43.....	1.41	8.25	55.96	1.57	29.47	1.60	98.26

Pyrometric Tests.

H 41. This clay started to bend at cone 28 and was fused flat at cone 30. In the preliminary burn this clay was vitrified at cone 20.

H 42. This sample was bending and bloating at cone 29. In preliminary burn it was vitrified at cone 20.

H 43. The final test on this clay was very unsatisfactory. When cone 29 was down, two of the cones made from this clay were beginning to bend, while the third one was erect. When cone 31 was touching the plaque, one of the clay cones that was started at cone 29 was flat and fused, while the other one, like the third clay cone, was vitrified and blistered, but not down. In the preliminary burn this clay was vitrified at cone 20.

Burning Tests.

These clays were made up into brickettes by the "stiff mud" process and burned at 1120° C. Each burned fine light buff and was quite porous.

Summary.

H 41 has a fair texture of fineness of grain, but the other members of this group are quite coarse. None of them show much plasticity. They are all comparatively low in iron content, and their relative fusibility corresponds or is roughly proportioned to their content of fluxing ingredients other than iron. Such factors as content of SiO_2 and and fineness of grain affect also to a considerable extent, their relative fusibility.

These clays belong to the refractory group, and offer possibilities of being satisfactory unless the low point of vitrification is objectionable. They seem also to be adapted to the manufacture of stoneware, terra cotta and No. 2 fire brick.

Clays from Macomb, McDonough County.
(Samples H 44, 45, 46)

FIELD NOTES.

These samples are reported to represent clays outcropping on the land of Dr. Russell, located one mile north of Macomb. The following sections were measured by the survey's representatives, while the samples were sent in later by Dr. Russell, and their exact source indicated by him.

Section No. 1 near Macomb.

	Feet.
Surface drift	3
Sandy rock	4
Fire clays (H. 44 from upper part)	3+

Section No. 2 near Macomb.

Surface drift	4
Shale, light colored	14
Shale, black and bituminous	2+
Fire clay (H 45 from upper part; H 46 from lower part)	10

LABORATORY NOTES.

Mechanical Analyses.

Sample.	Moisture.	Volatile.	Residue left on screens.					Finer than 200 mesh.	Total per cent.	Plasticity.
			20 Mesh	60 Mesh	100 Mesh	150 Mesh	200 Mesh			
H 44	0.82	4.00	0.161	3.04	16.56	28.84	6.14	24.88	82.64	D
H 45	0.66	2.96	6.265	4.24	2.60	6.11	7.26	37.65	67.75	D
H 46	1.24	3.94	0.101	0.56	3.41	21.02	3.64	65.82	99.73	C

Chemical Analyses.

Sample.	Moisture.	Volatile.	SiO_2	FeO_3	Al_2O_3	TiO_2	Total per cent.
H 44	0.33	4.31	78.46	1.29	13.97	1.02	99.38
H 45	0.49	3.03	83.34	0.80	8.42	0.80	96.88
H 46	0.81	4.32	77.88	1.05	14.42	0.93	99.41

Pyrometric Tests.

H 44. This clay started to bend at 27 and was just touching the plaque at cone 31. In the preliminary burn it was standing at cone 20.

H 45. The cones made from the clay began to bend at cone 27 and were flat at cone 29. In the preliminary burn this clay was vitrified at cone 20.

H 46. All cones were flat and fused at cone 29. No record was obtained as to when they began to fuse. In the preliminary burn this clay resembled H 45 in every respect.

Burning Tests.

H 44. Resulted in a coarse grained brick.

H 45. and H 46. gave sandy, porous bricks of buff color.

Summary.

The fusibility periods of these clays places them in the refractory class. All seem to be of possible use for fire brick. H 44 burns too coarse for use in pottery, but H 45 and H 46 seem of possible value for stoneware, terra cotta and No. 2 fire brick.

Clay from Streator, LaSalle County.
(Sample G 13)

FIELD NOTES.

Fire clay from mine No. 2 of the Chicago, Wilmington and Vermilion Coal Company, near Streator. The sample was obtained in the north entry, about 600 feet from the shaft, where it represents the top two feet of fire clay shown in the following section.

Section near Streator.

	Feet	Inch.
Hard shale	20+	
Bone coal		1
Coal (known as "No. 2 Coal")	2	6
Fire clay	11	
Black slate	1	

LABORATORY NOTES.

Mechanical and Chemical Analysis.

On account of the small size of the sample it was impossible to make satisfactory analyses.

Pyrometric Test.

In preliminary test this clay was vitrified at cone 20, and while thoroughly blue-toned, it was suspected that a further test might prove it to be a clay of higher refractoriness. In the final test which bears out this suspicion very nicely, the sample started to bend at cone 29 and did not go down much further at cone 30.

Burning Test.

At 1120° this clay burned to a nicely vitrified brick of buff color and coarse structure.

Summary.

As above indicated the pyrometric tests of this clay were somewhat contradictory. It hardly seems possible that the range from vitrification to fusion can cover 600° C, yet it can not be stated that such a case is an impossibility until more is known about the pyro-chemical behavior of clays belonging to this class. The final test seems to place this clay in the refractory group. The coarse structure of the burned brick furthermore suggests that it will make excellent paving brick.

Clay from Utica Fire Brick Co., Utica, LaSalle County. (Sample V 4.)

FIELD NOTES.

This is a blue clay taken from the pit of the Utica Fire Brick Company, two miles south of Utica. It immediately underlies an 18-inch bed of coal and averages about 12 feet in thickness.

LABORATORY NOTES.

Chemical Analysis.

Sample.	Moisture.	Volatile.	SiO_2	Fe_2O_3	Al_2O_3	TiO_2	Total per cent.
V 4.....	2.37	8.84	54.80	1.70	29.44	0.82	97.97

Pryometric Test.

The sample was slightly bent and showed a glassy fracture at cone 22 under reducing conditions. Under oxidizing conditions it was still straight though not carried beyond the vitrification point at cone 30.

Summary.

This clay contains 2 per cent of alkalies and alkaline earths. Judging from its behavior in the reducing fire, it may be inferred that the alkaline earths comprise the larger part of this 2 per cent of flux. The very high period of fusion indicates that this class of clay may be first class for fire brick.

Clay from Utica Fire Brick Co., Utica, LaSalle County. (Sample V 5.)

FIELD NOTES.

This is a yellow, blue-streaked clay that displaces the coal that would normally lie above V 4. The place where this strata is now being developed lies about one-fourth of a mile northwest of the pit where V 4 is being worked. At this place it is about five feet thick, overlaid by three feet of stripping. The Utica Fire Brick Company does not use this clay in the manufacture of their own ware but ship quantities of it tc the Illinois Steel Company, Deering Harvester Company, Illinois Zinc Company and others.

LABORATORY NOTES.

Chemical Analysis.

Sample.	Moisture.	Volatile.	SiO_2	Fe_2O_3	Al_2O_3	TiO_2	Total per cent.
V 5.....	1.76	9.18	55.86	3.09	27.09	1.06	98.04

Pyrometric Test.

This clay was not vitrified at cone 21, but began to bend at cone 30.

Summary.

The influence of the larger content of iron at the expence of alumina is responsible for the fact that this clay is more fusible than V 4. This clay has been used by the survey in making saggers and fritt crucibles for our own use, and found to be equal in every respect to the Christy fire clay of St. Louis.

Clay from Pioneer Fire Proofing Co., Ottawa, LaSalle County. (Sample V 11.)

FIELD NOTES.

This clay is found east of Ottawa in a pit owned by the Pioneer Fire Proofing Company, of Ottawa, Illinois. Here there are from five to eleven feet of this blue clay immediately underlying an 18-inch bed of coal.

LABORATORY NOTES.

Chemical Analysis.

Sample.	Moisture.	Volatile.	SiO_2	Fe_2O_3	Al_2O_3	TiO_2	Total per cent.
V 11.....	1.74	10.28	56.28	3.24	26.68	1.28	99.50

Pyrometric Test.

A sample of this clay was standing at cone 22.

Summary.

Judging from tests, this clay is probably from the same stratum as V 4.

At the time the pyrometric test on this clay was made, the laboratory stock of the higher cones was exhausted, so it was impossible to test this clay to the limit. Judging from its chemical analysis, however, it would pass for a first class fire clay.

Clays from White Hall Sewer Pipe and Fire Clay Works, Whitehall, Greene County. (Samples F 6 and 22.)

FIELD NOTES.

These clays are from the property of the White Hall Sewer Pipe and Fire Clay Works, 2¼ miles northeast of Whitehall. Their relations to the adjoining strata is shown by the following geologic section:

Section Near Whitehall.

	Feet.
Boulder clay; yellow; contains flint and crystalline pebbles	5 to 12
Loose sandstone, light yellow; unevenly stratified	6 to 10
Blue and yellowish shale. (F 22—yellowish)	25
Black, slaty shale	1
Coal. (Reported to be Coal No. 1)	3
Sandy shale; bluish	8
Fire clay; shale light gray, (F 6)	6
Green colored fire clay; shale	2

LABORATORY NOTES.

Chemical Analysis.

Sample.	Moisture.	Volatile.	SiO_2	Fe_2O_3	Al_2O_3	TiO_2	Total per cent.
F 6	1.38	6.17	67.37	1.59	21.69	1.32	99.52

F 22 was not analyzed.

Pyrometric Tests.

F 6. This sample was straight and dry at cone 22 and went down with cone 30.

F 22. This clay was straight, but vitrified at cone 22. It started to bend at cone 27 and was well fused at cone 30.

Summary.

The pyrometric test places these clays in the refractory class. F 6 is reported to be already in use for fire brick and for stoneware.

CLAYS FROM WESTERN STONEWARE CO., WHITEHALL, GREENE COUNTY.

(Samples F 16 and 17.)

FIELD NOTES.

These coal measure clays were obtained from the Western Stoneware Company at Whitehall and are said to be representative of the material mined at the two pits located about 2½ miles northeast of town. At the south bank where F 16 occurs the section is reported as follows:

Section Near Whitehall.

	Feet.
Yellow clay	15 to 30
Fire clay, (F 16) becoming sandy at base	15 to 20
Limestone	

At the north bank where F 17 is reported to occur the covering is, the same, but the fire clay is only 5 to 7 feet thick and is uniform from top to bottom.

LABORATORY NOTES.

Chemical Analysis.

Sample.	Moisture.	Volatile.	SiO_2	Fe_2O_3	Al_2O_3	TiO_2	Total per cent.
F 16.....	1.46	6.88	61.34	2.14	25.76	1.22	98.80

F 17 was not analyzed.

Pyrometric Tests.

F 16 was vitrified at cone 22 and went down with cone 30.

F 17. The cone made from this clay was straight, but vitrified at cone 20.

It began to bend over at cone 30; no record being taken beyond cone 30.

Summary.

These clays, while not fully tested, are placed by the fusion tests with the refractory class. It is possible that they may be suited to the manufacture of fire brick. They possess a long range of vitrification and seem adapted to use for stoneware, terra cotta and No. 2 fire brick.

Clays from Drake, Greene County.
(Samples F 18 and 19.)

FIELD NOTES.

These clays are said to be from the clay pits at Drake, F 18 representing the upper portion of the strata and F 19 the lower portion. The conditions here are said to resemble those at Whitehall, ten feet of good potter's clay passing into sandy shale below and covered by yellow drift clay.

LABORATORY NOTES.

Chemical Analyses.

Sample.	Moisture.	Volatile.	SiO_2	Fe_2O_3	Al_2O_3	TiO_2	Total per cent.
F 18.....	0.84	6.66	66.88	2 23	21.87	1.18	99.66
F 19.....	1.19	6.31	68.12	1.76	20.08	1.16	98.62

Pyrometric Tests.

F 18. This was slightly blistered at cone 22 and went down a little ahead of cone 30.

F 19. This clay was standing at cone 22, and was but slightly fused at the top at cone 30.

Summary.

F 18 is reported to be very popular as a stoneware and terra cotta clay, finding a market in a considerable number of states.

F 19 would be excellent material for many refractory purposes.

Clays from Ruckel & Son, Whitehall, Greene County. (Samples F 20 and 21.)

FIELD NOTES.

Clays were furnished by Ruckel & Son of Whitehall and are said to represent beds outcropping about one mile east of town. They are known respectively as the Ross and Purdy clays. The pit where the former occurs is reported to show the following strata:

Section at Ross Pit.

	Feet.
Yellow clay	4 to 30
Clay (F 20); upper layers nearly white; lower layers dark gray and sandy	12 to 15

LABORATORY NOTES.

Pyrometric Tests.

F 20. This clay was straight but vitrified at cone 22; at cone 27 it began to bend and at cone 30 it was well fused.

F 21. The test piece of this clay was straight but vitrified at cone 22; it started to bend at cone 24 and was down at cone 30.

Summary.

These samples evidently belong to the less refractory clays and seem to be best adapted to the manufacture of stoneware, terra cotta and No. 2 fire brick.

Clays of Miscellaneous Age and Origin.

In this group, as already explained, are included certain clays which on the map occur in areas where the Mississippian rocks occur, but which in part are of doubtful origin and age.

CLAYS OF MISSISSIPPIAN AGE.

In Pope and Massac counties two of the localities examined revealed clays presumably of Mississippian age. The general geology of this region has already been described* and the stratigraphic succession of limestones, sandstones and shales indicated. Though the rocks are displaced by numerous faults, it is quite likely that detailed work will reveal and trace one or more horizons at which occur siliceous shales or other refractory beds. Such occurrences are known in the adjoining area of Kentucky.†

*See Bul. 225 U. S. G. S. for descriptions and bibliography.
†See Prof. Pap. 36 U. S. G. S. for descriptions and bibliography.

Massac County Clay.
(Sample D 51.)

FIELD NOTES.

D 51. Sandstone or siliceous non-plastic fire clay from the farm of John Ridenour, Massac county, section 12, T. 16 S., R. 6 E. It crops out in a bed two feet or more in thickness in the bottom of a small side stream, just below and to the north of the farm house, and perhaps underlies a considerable area. It is probably of Mississippian age, since a well about one-eighth mile south and fifteen feet below this clay strikes Mississippian limestone at the mine of the Western Tube Company. The bed is slightly suggestive of the siliceous fire clay near Smithland, Kentucky, and is reported by Mr. Ridenour to have been tested and pronounced No. 1 grade by the Kewanee Fire Clay Company. While the bed does not appear to be of workable thickness, the fact can be easily determined and the bed exposed for shipment if warranted. The Ohio river is about three miles distant.

LABORATORY TESTS.

It is impossible at this time to report on the chemical and mechanical analyses of this clay.

Pyrometric Test.

While this material is very short and sandy, it is sufficiently plastic to mold into cones without the use of dextrine. In the preliminary test it burned white and at cone 20 stood without sign of vitrification. In the final test it was dry and infusible at cone 29.

Summary.

This would be a most excellent refractory material for places where acid operations are conducted. Its slight plasticity would permit of its being molded into bricks without much trouble. It might be used to advantage in the silica brick industry, and would seem to have an advantage over other material which usually requires hydrated lime or a similar bond to render the mass plastic.

Pope County Clay.
(Sample D 55.)

FIELD NOTES.

Clay from Pope county, section 35, T. 12 S., R. 6 E., on the southeast slope of "Flick Hill." This partial exposure shows four feet or more beneath a thin horizontally bedded sandstone ledge. Fifteen feet lower on the same hill occurs a second bed of gray clay shale, which possibly has slipped down from above.

The clay sampled is reasonably free from iron stain, is siliceous and homogeneous in character. It strongly resembles the fire clay near Smithland, Kentucky. It is probably of "Birdsville" age. On account

of topographic situation it is doubtful whether stripping is possible. The clay would probably have to be worked by means of drifts into the hill. Transportation facilities are very poor, the railroad being about five miles distant.

LABORATORY TESTS.

Incomplete tests were made on this clay, but the results may be of some value to those interested in the possibilities of the Mississippian clays.

Fusion and Burning Tests.

The sample fused down flat on the plaque at cone 18, but retained sharp edges. In the kiln it burned at 1120°C to a fine buff color.

Summary.

This clay is evidently low in iron except that in lump form. An eye examination does not reveal the conditions of the iron. So far as the evidence here obtained goes, the clay would be regarded by potters as a No. 2 fire clay, possibly of value for stoneware and building brick.

Clays of Doubtful Age.

In this group are included samples from two localities in the southern part of the State but widely separated. They have in common certain features, however, which suggest the bare possibility of like origin.

Clays from Raum, Pope County.
(Sample D 56.)

FIELD NOTES.

This material represents the "Kaolin" now exposed near Raum, in Pope county, at the old "clay diggings." The pit has been abandoned for many years, but apparently once contained a deposit of considerable commercial value. The clay is gray, waxy or greasy, and grades abruptly from its purer form into the associated red sandy clay. No considerable quantity of the better material now remains exposed. The local geology has been briefly described* and the present examination added little or further value towards determining the origin of the clay. There is apparently a fault here which brings St. Louis limestone into contact with Mansfield sandstone. While relations are obscure, the kaolin appears to occur along the fault zone, as though a decomposition product of older rocks or a secondary deposit intimately related to the faulting. No igneous rocks are known to outcrop in the immediate vicinity of the old pit.

Somewhat similar relations are revealed near Salem, Kentucky, at the Stevens clay mine.† Here a northeast southwest fault brings

*Bull. 255, U. S. G. S. p. 59.
†Mr. F. Julius Fohs of the Kentucky Geol. Surv., kindly visited this locality with Mr. De Wolf and interpreted the local geology.

St. Louis beds on the north side into contact with Cypress sandstone on the south, a vertical displacement presumably of more than 300 feet. The clay fills the fault zone, maintaining a width of twenty feet to a depth of eighty feet without sign of termination. The fault material is highly siliceous, with local greenish bodies of kaolin. It is perhaps a residual deposit derived from decomposition of quartzite and limestone. The kaolin, however, gives some evidence of having been "dragged" by the fault movement.

LABORATORY NOTES.

Partial tests were made of the sample from Raum, D 56, and also of material from the Stevens mine, D 49.

Chemical Analysis.

Sample.	Moisture.	Volatile.	SiO_2	Fe_2O_3	Al_2O_3	TiO_2	Total per cent.
D 56.....	4.62	9.84	58.06	1.23	26.57	0.14	100.46

D 49 was not analyzed.

Pyrometric Tests.

D 56. Infusible and dry at cone 29. In the preliminary test it exhibited a glassy sheen at cone 20, showing that vitrification had taken place to a considerable extent. There is no evidence at hand from which to judge the character of the fire gases in the preliminary test, but from the two tests studied together it is readily seen that the conditions of the fire gases, *i. e.,* whether they are reducing or oxidizing, will make some difference in the pyrometric value of this clay.

D 49. Began to bend after cone 20 was flat on plaque. Pure white in color. Blistered. It was beyond the vitrification period at cone 16; in fact, it was at the incipient fusion state at cone 16, but sligtly bent at cone 20, showing that it contains but very little flux other than the alkalies. Final test was not made.

Summary.

The plasticity of D 56 was graded as B. Judging from the chemical analysis and pyrometric test there can be no doubt that this clay is of high refractory value.

The Kentucky clay, D 49, although but partialy tested, gives evidence of being a fine white ware clay.

Clays from Kaolin, Union County, Illinois.
(Samples D 10, 11, 12, 13 and 14.)

FIELD NOTES.

This kaolin is from the pit of Goodman & Karraker, at Kaolin station, Union county, section 35, T. 11 S., R. 2 W. The works are

located about 200 yards west of the M. & O. R. R. and about twenty-five feet above it, in the lower portion of gentle hill. The clay has been exposed by stripping over an area about sixty feet in diameter, and it is reported to have been found for several rods under the hill to the west and north.

The exposed section shows loess, 10 feet; flint gravels, 2 feet; gray kaolin, 20 feet. Old pits are said to have been sunk eighty-four feet without reaching the bottom of the material and without deterioration in quality.

The geologic relations of this deposit are not clear on account of scarcity of rock outcrops. Certain properties, notably color, seem in the various pits to be vary regularly with depth, according to samples D 10, D 12 and reported observations. The gravel overlying the kaolin is a water laid bed, dipping slightly to the southeast and identical in appearance with beds of chert occurring in the same southern counties and thought to be of Tertiary age. It is possible, therefore, that the kaolin may prove to be a sedimentary bed of the same or earlier age and of considerable horizontal extent. Deposits of somewhat similar material, however, which exist in Pope county and in Kentucky seem to occur as alteration products along certain zones of faulting and suggest the possibility of the same relation in the present instane. Though no igneous rocks have been reported from Union county, they may well exist, and may bear a genetic relation to the kaloin. It is entirely possible, therefore, that further prospecting will show a considerable distribution of kaolin along a fault zone or as a mass of irregular shape and size.

The present annual output of this material is estimated by Dr. Goodman at 2,500 tons, valued at $2.00 to $2.25 per ton.

Summary.

These clays resemble kaolin in chemical composition, are quite fine grained, very refractory and exhibit a surprisingly high degree of plasticity. When burned they are not white, but have a deep buff color, due, of course, to the influence of the iron they contain. From the fact that they show practically the same behavior under reducing and oxidizing conditions, it can be inferred that iron is present in a combined form, as a silicate or titinate or some other stable compound. Under both oxidizing and reducing conditions they vitrify very slowly, due, no doubt, to the fact that they contain but a trace of such fluxing ingredients as lime, magnesia and alkalies. The clay is said to be used as a lining for copper retorts in the Lake Superior region. A much larger production could probably be obtained if the market warrants. It is suggested that the area should be prospected with the auger or drill; after which, if warranted, steam shovels or bucket elevators might be installed to advantage.

The first three samples, D 10 to D 12, inclusive, were not seen "in place," but were reported by Dr. Goodman to be representative of the deposit at its various depths.

D 12 is from a zone 35 to 40 feet below the surface.

D 11 represents a portion occurring from 40 to 44 feet down.

D 10 is said to be typical of that part lying 50 feet below the surface and extending to 84 feet.

The other two samples, D 13 and D 14, were collected from the stock cribs and represent the beds now worked from the top of the deposit to a depth of 20 feet. D 13 is slightly yellowish and is classed as No. 2. D 14 is white and is classed as No. 1.

LABORATORY NOTES.

Mechanical Analyses.

Sample.	Moisture.	Volatile.	Residue Left on Screens.					Finer than 200 Mesh.	Total per cent.	Plasticity.
			20 Mesh	60 Mesh	100 Mesh	150 Mesh	200 Mesh			
D 10.....	1.8	11.84	0.012	0.042	0.256	3.273	0.972	77.222	95.39	A
D 11.....	1.26	15.70	0.035	0.240	1.641	4.100	1.061	67.442	92.479	A
D 12.....	1.54	9.78	.....	0.205	0.267	1.518	1.734	79.761	94.80	A
D 13.....	1.40	12.48	0.652	0.579	1.004	1.049	0.784	78.781	96.73	A —
D 14.....	0.98	11.38	0.014	0.590	0.611	2.273	2.229	.....	18.077	A —

Chemical Analyses.

Sample.	Moisture.	Volatile.	SiO_2	Fe_2O_3	Al_2O_3	TiO_2	Total per cent.
D 10	1.25	9.90	43.90	1.76	40.79	2.40	100.000
D 11	0.97	15.37	48.30	1.02	31.14	3.20	100.00
D 12	0.86	8.64	56.55	1.23	29.97	2.75	100.00
D 13	0.90	9.05	47.95	1.23	37.86	3.01	100.00
D 14	0.87	10.61	52.65	0.97	33.98	2.92	100.00

Pyrometric Tests.

D 10. In preliminary test this clay was not fused at cone 19. In final test cone 28 was flat, while D 10 was still standing erect and gave no evidence of vitrification. The stock of cones above cone 28 was exhausted, so clay was not tested against higher cones.

D 11. This clay gave some evidence of incipient vitrification, when cone 28 was melted to a glass.

D 12. The cone was vitrified and its tip fused when cone 28 was melted to a glass.

D 13. Stood at cone 30 without fusion.

D 14. When cone 28 was flat this clay was erect, but gave evidence of incipient vitrification.

Map of Illinois, showing area of prevailingly acid soils and localities from which samples were taken for analysis.

LIMESTONES AVAILABLE FOR FERTILIZERS.

(By F. B. Van Horn.)

Contents.

Introduction.

In southern Illinois there is a considerable area lying south of the Shelbyville moraine and mainly east of the Kaskaskia river within which the soils are acid (see plate 4). This lies within the area of the Illinois drift, as discriminated by Leverett,* and includes the region mapped by the State Soil Survey as covered by the Lower Illinoian glaciation. The soils of this area have been the subject of study by the Illinois Agricultural Experiment Station for some time past, and plots have been laid out which have been treated with lime, phosphorus and legume to increase the production. Those treated with lime have shown a marked increase in productivity. The benefit from the lime does not lie in its direct action on the plant itself, but rather in that it makes acid soils neutral, contributing to the life of nitrifying bacteria. These liberate nitrogen, which becomes available to the plant, either as ammonia or as nitrates, and also liberate potash. According to Dr. C. G. Hopkins† of the Illinois Experiment Station, the annual cost of treatment for soils in this part of the State would be about $3.00 per acre. This cost includes ground limestone, phosphorus (applied in the form of steamed bone meal) and leguminose catch crops. By the use of these the output of the ground has been increased enormously. The station has experimental fields in the southern part of the State,

*Frank Leverett, Mon. U. S. Geol. Survey, N. 38, p. 26.
†Personal correspondence.

and it is reported that their results have been very satisfactory, but at present final results are not available for use. Preliminary tests indicate that in this part of the State the soils should be treated with from one and one-half to two tons of ground limestone per acre in order to obtain the best results. This will correct the acidity of the soil to a depth of about fifteen inches, the depth to which it may be incorporated with the soil by means of subsoil plows. According to Dr. Hopkins, "the use of lime or ground limestone in connection with the growing of clover, cow peas and other legume crops, especially when such crops have been turned under for green manures, as compared with using the same green manure crops without lime, has produced marked benefits. The results obtained on the University of Illinois soil experiment field near Odin, in Marion county, serve fairly to illustrate this. As an average of two plots each year during the past four years, the yield of corn has been increased 5.4 bushels per acre, and the yield of wheat four bushels per acre where lime has been used in connection with green manure, by cow peas, in addition to the yield produced where the same kind of green manuring was practiced without lime."* He says further: "Probably the most extended investigation ever conducted relating to the use of burnt lime and ground limestone in comparative tests is that reported by the Pennsylvania Experiment Station. After the experiments have been carried on for twenty years the results agree in indicating that ground limestone is a better form of lime to use for soil improvement than equivalent quantities of burnt lime. The experiments in Illinois have not been carried on far enough to justify conclusions which would compare in value with those obtained by the Pennsylvania station, but they have been sufficient to prove that in ground limestone, with other proper fertilizers, lies the secret of perpetuating southern Illinois soils."†

At the present time practically all the limestone used on the soils of Illinois is imported. This is unnecessary, since there are large areas of limestone within the borders of the State which may be used. Knowing the need of limestone suitable for agricultural purposes, samples have been collected from different parts of the State for the purpose of investigating their availability for use on acid soils. In the course of the past field season Messrs. DeWolf, Savage and Bain collected a number of samples from outcrops in this area which seemed suitably situated for development. These samples have been analyzed by F. W. Pate and A. W. Gregory of the Agricultural Experiment Station, and the thanks of the Survey are due to Professor Hopkins and his associates for their coöperation. The results of the analyses, together with notes as to accessibility, etc., of the rock are given below. While the present investigation has been by no means exhaustive, sufficient data have developed to warrant the following brief notes. The possibility of finding phosphates has also been kept in mind, and all members of the survey have taken samples of every stone which it seemed might carry sufficient quantities of phosphorus for commercial use. In all, nine such samples were tested. The analyses of these, however, do not justify any further exploitation.

*Personal correspondence.
†Personal correspondence.

Field and Laboratory Notes.

Union county.—At Anna, Union county, on the property of the Swan Creek Phosphate Company, S. E. ¼ of Sec. 17, T. 12 S., R. 1 W., is a limestone (D 2) which is now being developed for agricultural purposes. This stone is in the St. Louis formation, which underlies the country for several miles in this vicinity. It is exposed in a ledge twenty feet thick, but drilling has proven it to have a thickness of forty-five feet. The company plans to strip by hydraulic methods and convey the stone on moving belts to the crusher, which will reduce it to pass a two-inch mesh. Later it will be ground in Sturdevant mills to eighty mesh, when it will be ready for use. The analysis of this limestone shows it to be a very good one, containing 91.40 per cent calcium carbonate. The complete anlysis is given below.

Analysis, D 2.*

Insoluble matter	1.993
Calcium	36.616
Magnesium	2.259
Carbon	11.726
Phosphorus	.017
Fe_2O_3-Al_2O_3	.361
Oxygen	47.389
Total	100.361
$CaCO_3$ (Estimated)	91.405
$MgCO_3$ (Estimated)	4.402
Total	96.807

The railroad facilities for hauling this limestone, together with the ease of quarrying, make this locality a favorable one for obtaining limestone for agricultural purposes.

Johnson county.—Two beds of limestone (D 16 and 17) occur along the tracks of the Big Four railroad near Belknap, Johnson county. Samples taken by Mr. DeWolf from there showed the following analyses:

Analyses, D 16 and 17.*

D 16.		D 17.	
Insoluble matter	5.996	Insoluble matter	5.328
Calcium	36.067	Calcium	37.253
Magnesium	1.246	Magnesium	.686
Carbon	10.992	Carbon	11.072
Phosphorus	.038	Phosphorus	.023
Fe_2O_3-Al_2O_3	1.315	$Fe_2O_3Al_2O_3$	.829
Oxygen	44.569	Oxygen	44.871
Total	100.223	Total	100.062
$CaCO_3$ (Est.)	90.310	$CaCO_3$ (Est.)	92.360
$MgCO_2$ (Est.)	1.398	$MgCO_3$ (Est.)	
Total	91.708		

*Collected by Mr. DeWolf, analysis by Mr. Pate.

Mr. De Wolf gives the following section, showing the occurrence of the rock. Sections should be read from top down:

		Feet.	
8.	Sandstone	25	
7.	Unexposed	5	
6.	Coarse limestone	18	(D 16)
5.	Unexposed; showing both limestone and sandstone debris	20	
4.	Limestone; coarse, compact and oolite varieties; old quarry	15	(D 17)
3.	Limy sandstone	18	
2.	Limestone	15	
1.	Concealed to railroad	25	

Mr. De Wolf says: "It is doubtful whether the stone at this particular site can be utilized. It may be advisable to examine the place again in an effort to find a better outcrop of these beds. According to reports it ought to be possible to find a site for a limestone crusher without much difficulty."

From the analyses it is clear that the quality of this limestone is sufficiently good for agricultural use, and probably a suitable locality may be found for establishing a plant.

Alexander county.—Along the river bluff, one-half mile south of Thebes, Alexander county, Sec. 17, T. 15 S., R. 3 W., is an outcrop of Trenton limestone (D 42) which rises 35 feet from low water level and probably extends 15 feet above that, though it does not outcrop. It was sampled by Mr. De Wolf. The outcrop is perhaps 300 yards long, and could probably be worked from the west end of the bluff to the north and northwest with moderate stripping, but detailed surveying would be necessary to demonstrate the available quantity of workable stone. The analysis of this stone shows:

ANALYSES, D 42.*

Insoluble matter	.268
Calcium	39.907
Magnesium	.341
Carbon	11.658
Phosphorus	.036
Fe_2O_3-Al_2O_3	.318
Oxygen	47.259
Total	99.787
Calcium carbonate (Est.)	97.248
Magnesium (Est.)	

This certainly is a good limestone, and conditions here should be thoroughly investigated.

Pulaski county.—A sample was taken by Mr. De Wolf from an old quarry near Ullin, Pulaski county, Sec. 14, T. 14 S., R. 1 W. The section shows 60 feet of limestone overlaid by thin layers of clay and gravel. The sample analyzed (D 47) comes from the lower 40 feet, and gives the following analysis:

*Collected by Mr. DeWolf. Analysis by Mr. Pate.

ANALYSIS, D 47.*

Insoluble matter	6.385
Calcium	37.159
Magnesium	.655
Carbon	10.915
Phosphorus	0.026
Fe_2O_3-Al_2O_3	.494
Oxygen	44.400
Total	100.034
$CaCO_3$ (Estimated)	91.050

The old quarry extends about 400 yards in length, and has a face varying from 25 to 60 feet in height. Formerly a railroad spur connected it with the Illinois Central Railroad, and the rock was used for railroad ballast and concrete. It would seem that conditions are favorable for the quarrying of this rock.

Hardin county.—Limestone is abundant in this county and considerable quantities of calcite (D 52) must be handled at the Rosiclare mine in Hardin county, where it occurs as a gangue mineral. This calcite has ben used for soil treatment by farmers locally with excellent results, and it is possible that this material might be worked with a fair degree of profit. A good deal of it must be handled in separating the flourspar and ores from the gangue minerals, and it may be that the additional expense involved in preparing it for agricultural use would be warranted. The analysis by Mr. Gregory shows about 96 per cent calcium carbonate in this calcite.

Randolph county.—At the Southern Illinois Penitentiary at Menard, Director Bain sampled the limestone of the Chester formation now being worked in the crusher, and gives the following section:

		Feet.
7.	Loess and old weathered drift	2
6.	Limestone; coarse, conglomeritic (B 2)	6
5.	Limestone; fine grained, earthy with shaly partings, exposed north of the prison and being opened in new quarry. Sampled 10 feet thick, but thought to be 20-25 feet thick (B 4)	10
4.	Talus showing limestone blocks	10
3.	Sandstone, not constant	3
2.	Shale with thin limestone bands	10
1.	Limestone worked in prison yard (B 8)	42

The 42-foot bed of limestone (No. 1) is represented by sample B 8 composed of chips taken from top to bottom. The analysis of this indicates that it might well be used for soils, as it contains 95.573 per cent calcium carbonate.

ANALYSIS, B 8.†

Insoluble matter	1.896
Calcium	38.286
Magnesium	.931
Carbon	11.580
Phosphorus	.033
Fe_2O_3-Al_2O_3	.671
Oxygen	46.811
Total	100.210
$CaCO_3$ (Estimated)	95.573
$MgCO_3$ (Estimated)	.892
Total	96.465

*Collected by Mr. DeWolf. Analysis by Mr. Pate.
†Collected by Mr. Bain. Analysis by Mr. Pate.

Sample B 9 represents the accumulated dust around the crusher which is working on the same layer of rock. The content of calcium carbonate is 89.403 per cent.

ANALYSIS, B 9.*

Insoluble matter	4.917
Calcium	35.812
Magnesium	1.750
Carbon	11.154
Phosphorus	.052
Fe_2O_3-Al_2O_3	1.403
Oxygen	45.254
Total	100.342
$CaCO_3$ (Estimated)	89.403
$MgCO_3$ (Estimated)	3.070
Total	92.473

North of the prison grounds is an exposure of what is believed to be the same beds as occur in the grounds. A sample of this (B 6) shows 93.813 per cent calcium carbonate, and this could be used for agricultural purposes.

ANALYSIS, B 6.*

Insoluble matter	2.475
Calcium	37.581
Magnesium	1.115
Carbon	11.410
Phosphorus	.041
Fe_2O_3-Al_2O_3	1.106
Oxygen	46.209
Total	99.937
$CaCO_3$ (Estimated)	93.813
$MgCO_3$ (Estimated)	1.152
Total	94.965

Coles county.—Near Charleston, Ill., T. E. Savage collected a sample of Coal Measure limestone (S 3) which represents a thickness of approximately 18 feet. There are large quantities of this rock favorably situated for quarrying, and the analysis shows that it could be used for agricultural purposes. Crushed rock for road making could be obtained at this place, and the fine material could be used for liming soils. The analysis of this limestone is as follows:

ANALYSIS, S 3.†

Insoluble matter	3.907
Calcium	37.467
Magnesium	.711
Carbon	11.288
Phosphorus	.032
Fe_2O_3-Al_2O_3	1.559
Oxygen	45.559
Total	100.523
$CaCO_3$ (Estimated)	93.531
$MgCO_3$ (Estimated)	.534
Total	94.065

*Collected by Mr. Bain. Analysis by Mr Pate.
†Collected by Mr. Savage. Analysis by Mr. Pate.

Limestones were sampled at various other localities in the southern part of the State, but the analyses do not indicate that the stone would be particularly suitable for use on soils, so that these have not been included in this report.

Summary.

The following summary table shows the sample numbers, locations, and analyses of all the limestones covered in this paper:

Specimen No.	Location.	Insol.	Ca.	Mg.	C.	P.	Fe_2O_3 Al_2O_3	O.	Total.	$CaCO_3$ estimated.	$MgCO_3$ estimated.
D 2.....	Anna.....	1.993	36.616	2.259	11.726	.017	.361	47.389	100.361	91.405	4.402
D 16.....	Belknap	5.996	36.067	1.246	10.992	.038	1.315	44.569	100.223	90.310	1.398
D 17.....	Belknap	5.328	37.253	.686	11.072	.023	.829	44.871	100.062	92.360	.....
D 42.....	Thebes.....	.268	39.907	.341	11.658	.036	.318	47.259	99.787	97.248	.....
D 47.....	Ullin.....	6.385	37.159	.655	10.915	.026	.494	44.400	100.034	91.050	.....
D 52.....	Rosiclare....	.229	40.676	.238	11.532	.026	.914	47.171	100.786	96.196	.....
B 8.....	Chester	1.896	38.286	.931	11.580	.035	.671	46.811	100.210	95.573	.892
B 9.....	Chester.....	4.917	35.812	1.750	11.154	.052	1.403	45.254	100.342	89.403	3.070
B 6.....	Chester	2.475	37.581	1.115	11.410	.041	1.106	46.209	99.937	93.813	1.152
S 3.....	Charleston..	3.907	37.467	.711	11.288	.032	1.559	45.559	100.523	93.531	.534

From this it will be seen that there are at least seven localities in the southern part of the State where limestone occurs of sufficient purity as to probably warrant the erection of plants for preparing it for use on the acid soils. It is not certain, however, that all these places would be favorable. Further investigation would be necessary with regard to accessibility, railroad facilities, etc., before locating a plant, but it is certain that there are good openings in our own State for the exploiting of ground limestone for agricultural purposes, which would mean a considerable saving for the farmer. Since limestone is known to occur at other points in the area, sampling will probably result in the discovery of still greater resources of this material.

ANALYSIS OF CERTAIN SILICA DEPOSITS.

(By H. F. Bain.)

In southern Illinois in Union and Alexander counties, there are beds of fine-grained silica which is in demand in the wood polishing and numerous other trades. Three mills are now engaged in preparing the silica for market, and others are projected. The process of preparation consists essentially of fine crushing and careful sizing, since the value of any single grade is determined mainly by the fineness and uniformity of grain. These deposits were visited in 1906 by Mr. F. W. DeWolf, who took samples and made preliminary observations upon the mode of occurrence of the material. The origin and extent of the deposits is very imperfectly known and demands a thorough investigation, which it is planned to give. In the meantime partial analyses of certain representative samples have been made by Mr. L. C. Turnock under the direction of Professor S. W. Parr, and are given here as indicating something of the nature of the material. It is hoped that this will call the attention of manufacturers to the deposits and stimulate their further development.

Samples 211 and 212 were collected by Mr. T. B. Tuthill, of Anna, Illinois, and represent respectively the clear white and the cream-colored natural material. The other samples were collected by Mr. DeWolf. Nos. 205 to 209, inclusive, are from the works of the Illinois Silica Company at Reynoldsville, Union county. They represent the areated, velvetine, general, superfine, and cream grades respectively. No. 210 is from the McCotridge prospect in Alexander county, and represents a bed 40 inches thick.

Nos. 203 and 204 are from the William Simpkins farm near Thebes in Alexander county. They represent respectively beds 23 and 17 inches thick, these being separated by a bed 36 inches thick of red and blue flint and rusty silica. At all these places the material comes from surface pits.

The determinations made cover only such constituents as indicate definitely the character of the material. These have included throughout silica, iron and alumina. In a few cases ignition was also determined, but Professor Parr states that there is nothing more than hygroscopic moisture except probably in Nos. 209 and 212, where some water of hydration is undoubtedly present.

Analyses of Silica.

No.	SiO_2	Fe_2O_3—Al_2O_3	
	Per cent.	Per cent.	
203	87.90	3.72	2.84% loss on ignition
204	88.26	6.04	1.76% loss on ignition
205	95.14	2.38	
206	90.24	5.88	
207	95.18	1.04	
208	90.04	2.36	
209	73.78	14.56	4.62 Fe_2O_3 9.94 Al_2O_3 5.43% loss on ignition
210	97.20	1.28	
211	95.78	1.80	
212	77.82	10.26	7.915 Fe_2O_3 2.345 Al_2O_3

CONTRIBUTIONS TO THE STUDY OF COAL.

Contents.

Introduction.

[By H. F. Bain.]

Coal is the most important of the mineral resources of Illinois. A large share of the attention of the members of the survey has therefore been devoted to the study of coal and the coal fields of the State. In the Administrative Report the general nature of the studies undertaken has been indicated. In the following pages a few of the results now available are published. For a somewhat general statement regarding the coal fields of the State and the problems to be studied, the reader is referred to Bulletin No. 3 of the present survey, issued within the year.

The results here published are confessedly scattered and fragmentary. It is none the less thought worth while to print them, not only for the sake of making the matter available to the public, but also to submit our methods and plans to criticism while the work is still in progress. Our bulletins are essentially preliminary in form and purpose. In them the results of the work are brought up to date and given promptly to the public. Fuller and more complete discussion of the various topics is purposely deferred.

The following brief notes include certain discussions of the methods used in making our coal analyses, the results of our first set of analyses made on our own samples, certain preliminary results of tests directed toward the discovery of improved methods of using our coal, new determinations of the crushing strength of Illinois coal, and brief reports

on certain stratigraphic studies of particular interest to the coal industry. Professor Parr's studies of the possibility of anthracizing bituminous coal are sufficiently startling without additional comment. These studies are as yet entirely in the experimental stage. Through the coöperation of the University of Illinois the preliminary results here published have already been confirmed by a number of additional tests made on various different coals. A careful and elaborate investigation of the whole subject is now under way. After the experimental work is completed will be time enough to attempt to commercialize the process.

Professor Talbot's tests of the crushing of coal were made at the request of the State Mine Inspectors, who furnished the material used in making the tests. So far as is known these are the first tests made upon Illinois coals, and, indicating as they do, a much higher strength than it has been customary to assume, the need of further investigation is apparent. It is hoped that more work along this line may be taken up.

Mr. David White's studies of the stratigraphy of our beds were made at the expense of the U. S. Geological Survey, though in coöperation with our own corps. They have proven so fruithful that arrangements will be made, if possible, for their continuation, at least throughout another year.

Chemical Analyses of Certain Coals.

(By S. W. Parr.)

[Assisted by F. F. Grout, W. F. Wheeler, F. K. Ovitz and W. Brinsmaid.]

The methods employed in making the analyses given below may be briefly reviewed as follows: For obtaining the loss on air-drying the entire sample as received in sealed tins, was emptied into shallow pans and allowed to remain open at the temperature of the room until the weight became fairly constant. Ordinarily it was necessary to weigh the cans also, especially if water had condensed on the inside, and include this water in the loss on air-drying. The sample was next put through a small mill crushing to about buckwheat size. A portion of the crushed coal was further sampled out for finer grinding, and the remaining part sealed in "lightning" jars. This method, while slower, is to be preferred to the disc pulverizer with which the grinding of the first samples was done.

The methods for proximate analyses were essentially those recommended by the Committee on Coal Analysis of the American Chemical Society.* Sulphur was determined gravimetrically from the fusions as obtained in the Parr calorimeter. The carbon and hydrogen were obtained by means of the combustion furnace and the nitrogen by the Kjedahl method. Calorific values were determined by a platinum-lined Mahler-Atwater calorimeter; parallel determinations were made in the Parr instrument, the comparative results being given in the table below.

* Jour. Am. Chem. Soc., Vol. XXI, p. 1130.

In calculating calorific values from the ultimate analysis the factors used were 8080 for carbon; 34460 for the available hydrogen; and 2250 for sulphur.

The data obtained has been assembled further in a second table as a suggested method for better expressing the real properties of coal. In the arrangement the first three factors (a) constitute the sum of all the non-combustible constituents; the next group (b) comprises all of the combustible elements; the next group (c) contains those factors that directly indicate the characteristic of the coal with reference to the volatile or non-volatile nature of the combustible matter. The ratio $\frac{vc}{c}$ is found by dividing the volatile carbon (total carbon minus the fixed carbon) by the total carbon. This factor is the best ratio for showing the character of a coal. It is to be preferred to the "fuel ratio" as proposed by Frazer*, ($\frac{\text{fixed carbon}}{\text{vol. matter}}$) where both terms of the ratio are notably subject to variations and error in determination. It is to be preferred to the "carbon-hydrogen" ratio of Campbell† ($\frac{\text{total carbon}}{\text{total hydrogen}}$) where the hydrogen is a decided variable owing to the difficulty of arriving at a definite factor for the water content of the sample. The ratio here used, $\frac{vc}{c}$ has the advantage of having its larger term, the denominator, presumably accurate as to its determined value, while whatever error may attach to the other term, vc (total c—fixed c), resides in the fixed carbon, and the error is divided by the method of its derivation and association with the total carbon. The "gross coal index" is the reciprocal of the total combustible, and represents the number of pounds of coal in any case necessary to yield 100 pounds of actual combustible matter.

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* Trans. Amer. Inst. Min. Eng., Vol. VI, p. 430.

† Prof. Paper, U. S. Geol. Surv., No. 48, part 1, pp. 156-173.

Composition of Illinois Coals—Usual Constituents.

	Wilmington Coal. (Three Samples.)			Litchfield Coal.	Springfield Coal. (Two Samples.)			Blue Band Coal. (Thirteen Samples.)		
	Highest.	Lowest.	Average.	No. 84.	No. 81.	No. 82.	Average.	Highest.	Lowest.	Average.
Loss of moisture on air-drying	2.41	2.51	1.94	4.14	4.66	4.35	4.51	4.61	2.94	4.16
Analysis of Air-dried Sample—										
Proximate: Moisture	16.74	14.94	15.82	9.88	10.17	11.05	10.61	9.67	6.41	8.56
Proximate: Volatile matter	37.15	36.70	36.96	37.19	37.35	36.87	37.11	41.59	37.38	38.76
Proximate: Fixed carbon	41.13	37.33	39.44	45.74	41.04	40.61	40.82	44.27	40.56	42.50
Proximate: Ash	9.75	6.70	7.78	7.19	11.44	11.47	11.46	13.45	8.27	10.18
Ultimate: Sulphur	3.67	2.68	3.20	2.64	5.56	6.04	5.80	5.82	3.58	4.21
Ultimate: Hydrogen	4.15	3.77	3.95	4.77	4.12	4.23	4.17	4.59	4.10	4.35
Ultimate: Carbon	59.95	57.15	58.71	65.68	58.26	57.95	58.10	64.30	59.34	62.13
Ultimate: Nitrogen	.82	.75	.78	.98	.88	.88	.88	.93	.81	.86
Ultimate: Oxygen	10.11	9.14	9.76	9.16	9.57	8.38	8.97	10.98	8.74	9.71
Heat Units Determined—										
Calories	6,000	5,709	5,870	6,459	5,869	5,858	5,864	6,845	5,944	6,219
British thermal units	10,801	10,278	10,567	11,627	10,565	10,545	10,555	11,672	10,700	11,195
Analysis Calculated to Mine Sample—(Moist Coal)—										
Proximate: Moisture	18.00	16.56	17.45	13.61	14.36	14.92	14.64	13.36	10.33	12.36
Proximate: Volatile matter	36.33	36.15	36.24	35.65	36.61	35.27	35.44	40.01	35.72	37.16
Proximate: Fixed carbon	40.35	36.43	38.68	43.85	39.13	38.84	38.98	42.46	38.77	40.72
Proximate: Ash	9.52	6.59	7.63	6.89	10.90	10.97	10.94	12.87	7.92	9.76
Ultimate: Sulphur	3.58	2.64	3.14	2.53	5.30	5.78	5.54	5.56	3.44	4.03
Ultimate: Hydrogen	4.07	3.68	3.87	4.28	3.93	4.05	3.99	4.46	3.92	4.17
Ultimate: Carbon	58.82	55.77	57.57	62.97	55.55	55.43	55.49	62.40	56.71	59.56
Ultimate: Nitrogen	.81	.73	.77	.94	.84	.84	.84	.88	.77	.82
Ultimate: Oxygen	9.96	8.92	9.57	8.78	9.12	8.01	8.56	10.53	8.36	9.30
Heat Units Determined—										
Calories	5,886	5,571	5,797	6,192	5,596	5,603	5,600	6,294	5,679	5,961
British thermal units	10,596	10,030	10,363	11,146	10,073	10,086	10,080	11,329	10,224	10,730
Analysis Calculated to Pure Coal—(Ash and moisture free—										
Volatile matter	49.89	47.36	48.39	44.85	47.66	47.60	47.63	50.62	46.26	47.69
Fixed carbon	52.64	50.11	51.61	55.15	52.34	52.40	52.37	53.74	49.38	52.31
Heat Units Determined—										
Calories	7,708	7,665	7,682	7,790	7,489	7,563	7,526	7,834	7,495	7,653
British thermal units	13,875	13,799	13,830	14,022	13,481	13,613	13,547	14,100	13,494	13,775

Loss of moisture on air-drying	2.41	1.51	1.94	4.14	4.66	4.35	4.51	4.61	2.94	4.16
Analysis of air-dried sample—										
a Ash	9.75	6.70	7.78	7.19	11.44	11.47	11.46	13.45	8.27	10.18
a Moisture	16.74	14.94	15.82	9.88	10.17	11.05	10.61	9.67	6.41	8.56
a Inert volatile matter	11.67	10.41	11.32	11.04	11.12	10.34	10.73	12.95	10.53	11.47
Total non-combustible	35.93	33.51	34.82	28.11	32.73	32.86	32.80	31295	28.17	30.21
b Total carbon	59.95	57.15	58.71	65.68	58.26	57.95	58.10	64.30	59.34	62.13
b Available hydrogen	3.29	3.25	3.27	3.57	3.45	3.15	3.30	3.68	3.31	3.45
b Sulphur	3.67	2.68	3.20	2.64	5.56	6.04	5.80	5.82	3.58	4.21
Total combustible	66.49	64.07	65.18	71.89	67.27	67.14	67.20	71.83	68.01	69,79
Fixed carbon	41.14	37.33	39.44	45.74	41.04	40.61	40.82	44.27	40.56	42.50
Volatile carbon	19.82	18.82	17.27	19.94	17.24	17.34	17.29	23.00	17.42	19.63
c Ratio vc/C	34.6	31.4	32.8	30.4	29.5	29.9	29.7	36.2	29.1	31.6
Index	156.0	150.5	153.5	139.5	149.0	149.0	149.0	147.0	139.5	143.5
Heat units determined—										
Calories	6,000	5,709	5,870	6,459	5.869	5,858	5,864	6,485	5,944	6,219
British thermal units	10,801	10,278	10,567	11,627	10,565	10,545	10,555	11,672	10,700	11,195
Analysis calculated to mine sample (moist coal)—										
a Ash	9.52	6.59	7.63	6.89	10.90	10.97	10.94	12.87	7.92	9.76
a Moisture	18.00	16.56	17.35	13.61	14.36	14.92	14.64	13.36	10.33	12.36
a Inert volatile matter	11.45	10.16	11.00	10.58	10.60	9.89	10.24	12.42	10.07	10.99
Total non-combustible	37.48	34.77	36.08	31.08	35.86	35.78	35.82	34.59	30.28	33.11
b Total carbon	58.82	55.77	57.57	62.97	55.55	55.43	55.49	62.49	56.71	59.56
b Available hydrogen	3.23	3.17	3.21	3.42	3.29	3.01	3.15	3.55	3.15	3.30
b Surphur	3.58	2.63	3.14	2.53	5.30	5.78	5.54	5.56	3.44	4.03
Total combustible	65.23	62.53	63.92	68.92	64.14	64.22	64.18	69.73	65.42	66.89
Fixed carbon	40.35	36.43	38.68	43.85	19.13	38.84	38.98	42.46	38.77	40.72
Volatile carbon	19.34	18.46	18.89	19.11	16.44	16.59	16.52	22.13	16.64	18.82
c Ratio vc/C	34.6	31.4	32.8	30.4	29.5	29.9	2927	36.2	29.1	31.6
Index	159.9	153.3	156.5	145.1	153.9	155.7	155.8	152.9	143.4	149.6
Heat units determined—										
Calories	5,886	5,571	5,757	6.192	5,596	5,603	5,600	6,294	0,679	5,961
British thermal units	10,596	10,030	10,363	11,146	10,073	10,086	10,080	11,329	10,224	10,730

As a summary statement regarding these calorimetric results it may be noted that of the data as given, including the averages, the results in the third column include four which are higher than the corresponding results in the other two columns, one is lower, and five fall between results as found in the other two columns.

The accessory chemical used with the sodium peroxide was potassium chlorate, and the correction factor employed, including the wire for ignition, was 0.111° C.

Comparative Calorimetric Values.

Description.	Number of samples.		Mahler.	Calc. from ult. anal.	Parr.
Wilmington coal	3	Highest	6000	5909	5946
		Lowest	5709	5604	5684
		Average	5870	5754	5824
Litchfield coal		No. 84	6459	6509	6439
Springfield coal	2	No. 81	5869	5841	5809
		No. 82	5858	5913	5862
		Average	5864	5877	5886
Blue Band coal	13	Highest	6485	6467	6454
		Lowest	5944	5964	5983
		Average	6219	6194	6250

The samples used in this work form a portion of a systematic series of vein samples collected by the State Geological Survey. The moist coal analysis represents the coal as it occurs in the ground. The air-dry analysis represents it in the condition of laboratory manipulation, and is our basis for calculation. Details regarding the plan of the work are given in the accompanying Administrative Report, and in Bulletin No. 3 of this survey, already issued. As the work is still in progress, further discussion is deferred. The Blue Band coal used in this work was obtained from the following mines:

Hillsboro, 2 samples; Divernon, 4; Mt. Olive, 3; Staunton, 2; O'Fallon, 2.

Determination of Moisture Lost on Air Drying.

[By F. F. GROUT.]

In beginning the chemical work on Illinois coals the determination of moisture was found to be in a very unsettled state. In our determinations, therefore, while the usual methods have been employed, the results have been studied and in some cases checked by slightly varying the process in the hope of discovering new facts or better methods. It is quite generally admitted that a moist coal sample should be air-dried before pulverizing; and even then, the majority of workers find an additional loss of moisture during the pulverizing process. The kind of puverizer used probably has a good deal of influence on the amount of moisture lost. Professor Lord reports an experiment indicating a loss of moisture by grinding in an open mortar of .77 per cent more than a sample ground in a jar-mill.*

* U. S. Geol. Survey. Prof. Pap. 48, p. 293.

In addition to certain tests of air-drying we have tried to find the effect of one type of pulverizer—the "Braun Disc Pulverizer."

In doing the work of the State Geological Survey most samples as received were divided into two parts, one being air-dried at once. The second was sealed in a "Lightning" fruit jar and dried after about two months standing. The results varied so much—due apparently to the varying humidity of the air in the room—that the change in the moisture content resulting from standing in the rubber sealed jar could not be defined. In coals which lost 6 per cent to 8 per cent moisture on air-drying, the variations due to humidity and surroundings were as high as 2 per cent, and it required no accurate determination of humidity to foretell whether results would be high or low. Drying in different rooms of the chemistry building proved to affect the loss; a result of better ventilation or greater heat in some rooms.

In a specific case six coals were dried 24 hours, as usual, in a well ventilated basement room. They showed the following losses:

Loss of Weight on Air Drying.

Sample.	No. 58.	No. 59.	No. 60.	No. 61.	No. 62.	No. 63.
Weight moist	390.51	405.98	401.06	406.50	424.10	414.06
Weight dry	385.03	400.00	390.10	399.00	413.58	407.06
Loss of weight	5.48	5.98	10.96	7.50	10.52	7.00
Per cent lost	1.41%	1.48%	2.74%	1.75%	2.48%	1.69%

Samples No. 59, 61 and 63 were left in the same place 24 hours longer and reweighed, but there was no further change. Samples No. 58, 60 and 62 were exposed in another laboratory for an additional 24 hours and reweighed with the following results:

Loss of Weight on Additional Air-Drying.

Sample.	No. 58.	No. 60.	No. 62.
Weight moist	385.03	390.10	413.58
Weight dry	383.71	386.06	411.45
Loss of weight	1.32	4.04	2.13
Per cent lost	.34%	1.03%	.51%

The results show an average further change of .63 per cent due to exposure in a different room.

It was noticed in many cases that mine samples after being sealed in a fruit jar several weeks developed some gas pressure and it was suspected that some change in weight might be found after the pressure was relieved; but in the ten samples tested the change after two months was too small to be weighed.

The disc pulverizer was used on all samples numbered 1 to 130. On an average, 150 grams of coal were pulverized, as it was thought a large quantity would tend to reduce the percentage of error due to the pulverizer. The average time a sample of coal was exposed to the air and in the machine was about ten minutes. As a whole the instrument seemed satisfactory, but two defects developed. First, after about 300 grams had been ground, the disc grew so warm as to increase the loss of moisture. Second, the powder was so fine and so suspended in the air that much of the dust sifted out around the edge of the receiving pan and collected under it, though little seemed to get outside of the machine. On 35 samples tested the combined loss of dust and moisture ranged from 6 to 13 grams out of 150 grams—averaging 9.5 grams or 6 1-3 per cent. Of this, at least 4.4 per cent, was due to dust losses, and not all the dust was collected. The possible loss of moisture is accordingly below 2 per cent. The following tests indicate that it is very much lower.

Four samples showing considerable range of moisture were selected, and the moisture was determined in both the 20-mesh crushed sample and the 100-mesh pulverized sample after 48 hours air-drying and 72 hours drying over sulphuric acid in a vacuum. To make certain of a representative lot 20 grams of the 20-mesh sample were taken. No. 80 was ground in a rather hot machine; No. 89 in a cold machine. No. 39 and 73 were ground in the machine at average temperature.

Percentage Loss of Moisture.

Sample.		No. 39.	No. 73.	No 80.	No. 89.
48 hours air-drying.....	20-mesh	4.84%	.58%	2.32%	1.13%
	100-mesh	4.11	.87	2.20	1.51
	Difference.....	.72	.29	.12	38
Additional on 72 hours in vacuum.	20-mesh	3.66	5.11	5.26	9.63
	100-mesh	3.62	4.17	3.76	9.31
	Difference.....	.04	.94	1.50	.32
Total loss.....	20-mesh	8.49	5.69	7.58	10.76
	100-mesh	7.73	5.05	5.96	10.84
	Difference.....	.76	.64	1.62	.08

Assuming therefore that there is no loss of moisture due to grinding to 20-mesh, coal having 8 per cent moisture content will lose about .75 per cent while being pulverized to 100-mesh. It is safe to say that, if the machine is not allowed to get hot, the coal will not lose much more or less than one-twentieth of the original moisture, and this figure would be a fair one to propose as an approximate correction where this method of grinding is used, in calculating the analysis to the sample as received.

Moisture in Air-Dried Samples.

[By W. F. WHEELER.]

When the investigation of Illinois coals was taken up by the Illinois Geological Survey, the determination of moisture in the air-dried sample was in almost as unsatisfactory a state as the determination of moisture lost in air-drying. The method first used was that commonly employed in analytical laboratories. One gram of coal was weighed into a crucible, either porcelain or platinum, and then dried in an air bath for one hour at 105° C. The crucible was then allowed to cool in a desiccator, and weighed as soon as possible. It was soon shown by the variation of the results obtained that coal took up moisture from the air in the desiccator. The following results show a fair average of the variation due to the use of crucibles without covers in calcium chloride desiccators:

	Without Covers.	With Covers.
	Per Cent.	Per Cent.
Moisure (a)	9.04	9.29
(b)	9.01	9.25
(c)	9.02	9.26
(d)	8.98	9.20
Average	9.01	9.25

To prevent this absorption the crucibles were covered when they were taken from the air-bath, and kept covered while weighing. This change in method secured a much better agreement of results, but still left a great deal to be desired.

The next weak point in the determination was found in the desiccators themselves. The coal was found to take up moisture from the calcium chloride of the desiccator, so that was replaced by concentrated sulphuric acid, and still further improvement in the accuracy of the determination noted. Even then it was not wholly satisfactory. When more than two crucibles were placed together in a desiccator the last ones to be weighed showed a low moisture result, the amount of the error depending upon the number of times the desiccator had been opened, and also upon the time between weighings. To overcome this difficulty it was found to be necessary to put but one crucible in a desiccator while cooling. These difficulties are due to the fact that the coal itself has almost as great an affinity for moisture as the material in the desiccator, and whenever it has a chance it will absorb moisture.

At present we have given up the use of crucibles and use instead glass weighing bottles with tight fitting glass stoppers. By using bottles instead of crucibles and stoppering them tightly as soon as

they are removed from the drying-oven we preclude all possibility of the coal taking up moisture from the air, or from the desiccator, and moreover we do not have to provide a desiccator for cooling each determination. By the use of weighing bottles and a toluene bath, with one hole in the top open for ventilation, results were obtained that showed a very close agreement. In a series of 56 the average variation in duplicate determinations was only .04%, whereas, with the greatest care when using crucibles the variation of results was much greater.

For drying coals we now use a toluene bath without a positive air circulation, filled with the ordinary room air of varying moisture content. Undoubtedly the moisture in the air has an appreciable effect on the moisture results obtained by this method, and to overcome this we are soon to change our drying oven so as to use a current of air dried by passing through sulphuric acid, and thus make our moisture determinations absolutely independent of weather conditions. The above results all point to the necessity of conforming to the method adopted by E. E. Somermeier* of the coal testing plant at St. Louis.

Some experimental work was done in comparing moisture results obtained by drying in a vacuum desiccator over sulphuric acid for forty-eight hours and in the toluene bath. The result of twenty or more of these comparisons shows the figures obtained in the vacuum desiccator to be higher by nearly .3%. Dr. Hillebrand* shows the vacuum desiccator to give results .35% higher than the toluene bath. This lack of agreement of results seems to indicate that the moisture is not all removed from the coal in the air oven or the toluene oven at 105°-107° C in one hour. We hope soon to have results comparing the vacuum desiccator and the toluene oven using dried air, and expect to find closer agreement between them than the present results seem to indicate.

Anthracizing of Bituminous Coal.

[By S. W. PARR.]

A number of preliminary experiments were made in 1902 having in mind the possibility of producing artificially those changes which coal has presumably gone through in passing from the bituminous to the anthracite condition. The desirability of attaining that end was accentuated at the time by the coal famine in the anthracite region. Subsequent studies on coal, embodied for the most part in Bulletin No. 3 of the Illinois State Geological Survey, while not directed primarily to this same end, have contributed a number of facts concerning the character and composition of coal as a chemical compound which strengthens a theory then derived, though they do not furnish data for its corroboration.

A preliminary statement of results is here made with the expectation that the work may be resumed. If verification and extension of the earlier data are obtained, a basis will then be afforded for its practical application.

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* Jour. Am. Chem Soc. Nov., 1906, p. 1630.

† Prof. Paper No. 48, U. S. Geol. Surv., p. 295.

The advantages which would result from such a process can hardly be over-estimated. For example, the gross tonnage upon which freight charges are based would be reduced one-fifth; that is, the same amount of potential fuel would be transported with one-fifth less gross tonnage. On the basis of an annual shipment of 30,000,000 tons at an average freight charge of 50 cents per ton, the saving would be $3,000,000. A further element in the case would be the absence of smoke in the processes of combustion with the attending conditions of increased efficiency, and lessened contamination of the atmosphere. It is not unlikely also that studies along this line will contribute much to our understanding of matters pertaining to the coking of coal, and the increased yield of both the coke and the attending by-products.

The results as tabulated below have been tabulated to a common ash unit, as a basis for comparison. By this means it is shown more readily that the fixation of carbon in the non-volatile form has been increased by over 25 per cent with a corresponding decrease in the volatile constituents, to a point indeed where the formation of smoke on combustion is eliminated.

Modification of Chemical Structure of Coal—Preliminary Experiments.

	Normal Temperature.	After Heating at Approx. 250° C. One Hour.		After Heating at Approx. 500° C. Ten Minutes.	
		First Exper.	Second Exper.	First Exper.	Second Exper.
Moisture	6.49	0.00	0.00	0.00	0.00
Ash	6.69	6.69	6.69	6.69	6.69
Volatile matter	33.27	5.13	12.69	0.00	0.00
Fixed carbon	53.55	72.23	66.45	72.60	60.10
Increase of fixed carbon	.....	34.90	24.00	35.50	29.10
Loss of volatile matter; chiefly non-combustible	.....	15.95	14.16	20.71	24.21

Cannel Coal in Northern Illinois.

[By F. F. GROUT.]

At two localities in northern Illinois lenses of cannel coal occur in connection with coal of ordinary bituminous type. It is possible that it may prove to have stratigraphic value, and serve, if sufficiently wide spread, as an aid in correlating the seam from place to place. The unusual occurrence and character of this coal was thought to be sufficient warrant for making the analyses quoted below.

The cannel is found in elongated lenses up to a foot or more in thickness, perhaps 100 yards long on an average. These were seen most often above the rest of the coal, adding to the total thickness and not replacing the coal of the normal seam. At Colfax a similar bed was found below the coal. The cannel is often properly rejected as

"slate," but inasmuch as the ash content gets as low as 22 per cent in some cases, it has considerable fuel value and is loaded with the rest of the coal in some mines, as at the Matthiessen and Hegeler Zinc Co., LaSalle. Three samples were tested with considerable variation in results.

Number.	Water.	Vol. Mat.	Fixd. C.	Ash.	Carbon.	Hydrogen.	Oxygen (Est.)
1.....	2.78	41.26	30.20	25.76	49.78	6.09	13.39
2.....	4.02	30.98	30.39	34.61	.....	.....	.....
3.....	4.28	39.71	33.66	22.35	.....	.....	.....

These incomplete results are sufficient to show the cannel-like character of some of the lenses. The first, for example, has 6.89 per cent of hydrogen in the pure coal (ash and water free), which is higher than is found in the bituminous type. The occurrence of this coal warrants further investigation, but in the meantime it is thought well to put the the analyses on record. Samples No. 1 and 2 were taken in the mine of the Colfax Coöperative Coal Company, at Colfax, in McLean county. The former represents a 6-inch layer found throughout the mine at the base of the usual bed of coal. No. 2 represents a lense of cannel having a maximum thickness of 10 inches and found above the coal on one side of the shaft. This upper bed of cannel represents irregular lenses usually not more than 100 feet in horizontal extent. The coal at Colfax is commonly referred to as the No. 6 bed.

Sample No. 3 was taken in the Matthiessen and Hegeler mine at La Salle. In the mine a coal is worked which lies above the usual "third vein" of the northern field and resembles the Springfield coal in character. The cannel coal occurs in irregular thin lenses on top of the regular bed, through perhaps one-third of the territory so far opened.

Compression Tests of Illinois Coal.

[By A. N. TALBOT.]

The following tests were made in the Laboratory of Applied Mechanics of the University of Illinois upon samples furnished by the State Geological Survey. This work was done in response to numerous requests for information regarding the strength of our coals. The data regarding the source of the samples is furnished from the survey office.

Source of Samples Tested.

Lab. No.	Specimen from.	Collected by.	Geological number of bed.	Remarks.
12401.....	.....	.....	.....	.....
12402.....	Empire Coal Co., shaft No. 3, Gilchrist, Ill.	Supt. H. M. Gilchrist and Thos. Hudson...	"No. 1".....	Top of bed here 4 feet 2 inches thick.
12403.....	Penwell Coal Co., Pana, Ill.....	W. W. Williams.....	.....	Bottom of bed.
12404.....	Herdien Coal Co., Mine No. 16, Galva, Ill....	Thos. Hudson.....	"No. 6".....	Top of bed here 4 feet thick.
12405.....	Illinois Collieries Co., Shaft No. 7, Litchfield, Ill.....	T. H. Watson,.....	"No. 1".....	.....
12406.....	Chicago, Wilmington and Vermillion, Mine No. 2, Streator, Ill..	H. C. McAllister.....	"Third Vein" "No. 2".....	.....

The coal was sawed or chipped to make blocks approximately fairly well to prisms of the dimensions given in the table accompanying this report. The test blocks were bedded in a coat of plaster of Paris above and below, and this plaster was allowed to set two hours or more under a low load. The tests were made with the 60,000 lb. testing machine of the Laboratory of Applied Mechanics. The load was applied with a machine speed of 1-20 inch per minute.

The second table gives the dimensions of the test piece and the maximum load taken by the specimen. A log of the tests showing at what load cracks appeared and cracking sounds were heard follows. The amount of shortening of the specimen under load is given for three tests.

The exceptionally high strength of this material is somewhat surprising. The fact that minute cracks appear at low loads and that cracking sounds were heard early in the test should also be noted. It is also of interest that the specimens showed from $\frac{1}{8}$ to $\frac{1}{4}$ inch shortening per foot of height.

Compression Tests of Illinois Coals.

Lab. No.	Equivalent Section Inches.		Height Inches.	Maximum Load.	
	Top.	Bottom.		Pounds.	Lbs. per sq. in.
12401	$11\frac{3}{4}$ x 12	$11\frac{3}{4}$ x 12	$12\frac{1}{2}$	316,000	2,090
12402	$15\frac{1}{8}$ x $17\frac{3}{8}$	15 x $15\frac{3}{8}$	11.3	540,000	2,170
12403	$13\frac{1}{4}$ x $13\frac{1}{4}$	14 x 14	$14\frac{1}{2}$	186,000	1,000
12404	$11\frac{1}{2}$ x $17\frac{1}{4}$	16 x 13	12	208,000	1,020
12405	$13\frac{3}{4}$ x 12	$13\frac{3}{4}$ x 12	15	224,000	1,360
12406	$11\frac{3}{4}$ x $9\frac{1}{4}$	11 x $11\frac{1}{4}$	13	140,000	1,280

LOG OF TESTS.

No. 12403, Penwell Coal Co., Pana, Ill.

Applied Load.	Shortening.	Remarks.
7,000	.000	Initial load.
36,000	.000	Set deflectometer at zero.
50,000	.005	
75,000	.020	Slight cracking sounds.
100,009	.032	
125,000	.053	
150,000	.070	Vertical cracks appearing.
175,000	.090	Vertical cracks enlarging.
186,000	.....	Maximum load.
160,000	.....	Edges spalling off.

No. 12404, Herdien Coal Co., Galva, Ill.

5,000	.....	
15,000	.....	Slight cracking.
25,000	.028	Slight cracking.
50,000	.045	
75,000	.061	Loud cracking.
100,000	.075	
125,000	.095	South side spalling off.
150,000	.115	
175,000	.140	
200,000	.161	
225,000	.190	
250,000	.220	Southeast corner fell off.
275,000	.260	Corners falling off.
280,000	.....	Maximum load.

No. 12405, Illinois Collieries Co., Litchfield, Ill.

6,000	.....	
25,000	.024	Slight cracking sounds.
50,000	.045	Slight cracking sounds.
75,000	.055	
100,000	.070	
125,000	.085	Cracking sounds all over.
150,000	.101	
175,000	.120	Loud cracking sounds at corner.
200,000	.138	Vertical cracks on south side.
224,000	.....	Maximum load. Corners broke off all round.

No. 12401,

Applied Load.	Remarks.
6,500	Initial Load. Plaster set about 48 hours.
140,000	Cracking sounds first heard.
235,000	Cracking sounds all over specimen.
275,000	Bulging. Corners fall off.
316,000	Maximum load. Crushed into small pieces.

No. 12402, Empire Coal Co.

3,600	Initial load. Plaster set about 4 hours.
28,090	Popping noises.
15,000	Spalling off.
39,000	V shaped cracks begin to open on sides.
51,000	Large pieces spalling off on sides.
525,000	Large V shaped cracks.
540,000	Shattered.

No. 12406. C. W. & V. Coal Co., Streator, Ill.

45,000	Cracking sounds first heard.
75,000	Louder cracking sounds.
90,000	Vertical cracks appearing.
120,000	Edges spalling off.
130,000	Corners breaking.
135,000	Vertical cracks larger.
140,000	General shattering.

Report of the Field Work in the Coal Districts of the State.

[By DAVID WHITE.]

The task undertaken by myself included a preliminary examination of various areas of the Illinois coal field for the purpose, (1) of ascertaining through the aid of fossil plants the time relations or equivalents of the groups of the Illinois Coal Measures in the typical sections of the eastern basins; and (2) of determining the extent to which the fossil floras which accompany the coals may be used for the local identification and correlation of the individual beds in different parts of the Illinois coal field. In carrying out this paleobotanical reconnoissance, hasty examinations were made at a number of points in the mining districts of the northern, western, and southern portions of the State. The total time available for the work was about six weeks. Under the circumstances, therefore, the examinations were necessarily hurried and incomplete. Not having had opportunity to open or examine the collections since returning from the field I am obliged to confine this report to a statement of the regions visited, and to such comments or conclusions as were reached in the course of the field examination of the material collected.

The flora of the so-called "No. 2" coal in the vicinity of Morris, Grundy county, has long been well known, and, since it comprises the most complete and characteristic flora yet brought to light in the State, has been taken by me as a sort of a paleobotanical base line in making comparisons with the fossil plants from other horizons or regions of the coal field. This flora, which is typically present at Minonk, in Woodford county, appears also to be developed in the roof of the so-called third vein of the LaSalle and Spring Valley mines, and also at one of the small mines south of Peoria. The fossils from the roof of the coal at Colchester, in McDonough county, are not in such complete agreement with the Morris flora as would naturally be expected in view of the correlation of the Colchester coal with the same bed by the State geologists and mine inspectors. The matter of the relations of the coals worked in McDonough and Grundy counties deserves further and more careful consideration. The Morris, or "No. 2," coal of Illinois lies probably at or near the horizon of the Lower Kittanning coal of Pensylvania.

Such brief examinations as I was able to make in the regions in which "coal No. 1" is supposed to be exploited are interesting or important chiefly for the discrepancies discovered in the prevailing correlation and nomenclature of the coals. The evidence obtained at several points in Rock Island county goes to show that the refractory

fire clay mined along the Mississippi river in this region belongs in the Upper Pottsville, and not far from the level of the Sharon coal. It is the horizon of most abundant *Megalopteris*. The adjacent Muscatine sandstone which falls at an approximate paleobotanical level, in the Upper Pottsville, is the source of the *Lesleya grandis,* described as having been derived from the Chester. The plants, which I had time to collect only in insufficient quantity, from the roof of "coal No. 1" in this county are clearly of Pottsville age, and lie, perhaps, within the limits of the Connoquenessing sandstones (Upper Pottsville) of the Appalachian trough. Additional material is needed for the definite determination of their horizon, but it seems probable that a considerable interval elapsed between the deposition of this coal and that of "No. 2," in Grundy county.

The attempt to secure paleobotanical material from the coal regarded as "No. 1," in Scott county, was largely unsuccessful, possibly on account of lack of time; but the shales over the supposed representative of this bed in the deep mine at Litchfield furnishes a flora perhaps not older than that of the Mercer group, or uppermost Pottsville. This is the most surprising in view of the fact that in the southeastern portion of the coal field, at Battery Rock, Hardin county, the coal known as "No. 1" in the State reports lies about one hundred feet below a coal shown by its flora to be, probably, of Lower Pottsville age. In short, it appears that in southeastern Illinois there were deposited representatives of the Lookout formation, of Lower Pottsville age, and a portion, at least, of the Middle Pottsville, prior to the deposition of the earliest Upper Carboniferous sediments in the northwestern portion of the state. It is probable that these, the oldest of the Illinois Coal Measures, were laid down when the basin was greatly restricted, and included only a small part of the present coal field. The deposition of the "No. 1 coal" of the northern part of the State was possibly only after a considerable subsidence of the deeper portions of the basin. No less than four coals were laid down in Hardin county before the formation of the deep coal at Litchfield, and three, at least, of these coals antedated the so-called "No. 1" seam of Rock Island county. Time was not available for the collection of the fossils necessary to the definite correlation of the older coal horizons in the southern region though they will be tentatively brought within certain limits when the collections now in hand have been studied.

Good fossil plants, especially fossil ferns which are of greatest correlative value, are in general so rare in the shales immediately overlying the higher coals now mined at the localities visited in the State that but little material was gathered from this part of the coal measures in the course of my work, and these from but two or three points From the field examination of these scanty collections I am disposed tentatively to regard "coal No. 6" as probably belonging to the Freeport group of the Pennsylvania series. Hence the section including the Morris "No. 2" coal and the "No. 6" coal appears to fall within the Alleghany Series, or "Lower Productive Measures" of Pennsylvania. The great rarity of satisfactory plant material in the roofs of these coals at most localities is a source of great disappointment to me

since it makes it seem probable that paleobotany will be of little service in an attempt at the local identification of the individual beds in this portion of the section. It is interesting to note in passing that notwithstanding the absence of well preserved fern material in the roof shales of the coals, the distinct preservation of small fragments of pinnæ and pinnules in the coals themselves is not rare. The coals are in general characterized by enormous quantities of mineral charcoal, or mother of coal, in the laminæ of the beds, many of the individual fragments being of unusual size. Among the latter it is easy at many localities to recognize cortical fragments of *Lepidodendron, Lepidophloios, Sigillaria and Calamites.*

From my observations in various parts of the Illinois coal field I am very strongly impressed with the great extent, continuity, and regularity of the individual coal beds, especially coals "5" and "6." The relative regularity in the intervals and structure of the beds points to an extraordinary degree of uniformity in deposition of the Illinois Coal Measures as compared to the coal series in the Appalachian trough. Yet, in view of the striking incompatibilities attending the designation of the various coals at present known as "No. 1" not only in Illinois, but in Kentucky as well, I would strongly recommend the discontinuance of the numerical form of nomenclature as soon as and wherever practicable.

Owing to the limited time available for work in the State some of the districts, especially in the central and eastern portions of the coal field, and in Williamson and Jackson counties, could not be visited. For the same reason no examination was made of the higher, or "barren series," of the Illinois Coal Measures.

The Delafield Drill Core.

[JON A. UDDEN.]

During the first year of the State Geological Survey's existence it has been very fortunate in procuring records of a number of deep wells and prospect holes that have been made in various parts of the State. Records of this nature are of great assistance in interpreting the geology of a region, and give the only directly obtainable data on the nature of the underlying formations.

Within the past year two companies have been prospecting for coal in Hamilton county. At Delafield, the Delafield Coal Company put down a prospect hole 920 feet deep, finding nine veins of coal, ranging in thickness from three inches to five feet and three inches. The Elm Grove Coal Company put down a hole 1,294 feet deep encountering seven veins of coal ranging in thickness from three inches to seven feet and six inches. The Acme Diamond Core Drilling Company of St. Louis, Mo., had charge of the making of both of these prospect holes.

The record of the Delafield Coal Company is of especial interest on account of the comparative completeness of the core and log as kept by the men in charge of the work. The Elm Grove Coal Company's boring is interesting on account of being the deepest hole that has been made in Hamilton county.

THE DELAFIELD COAL COMPANY'S BORINGS.

The Delafield Coal Company's prospect hole is located on the west half of the northeast quarter of section 34, T. 4 N, R. 5 W., Hamilton county. The rocks penetrated in this hole are of Carboniferous age and are all included in the Pennsylvania or Coal Measure Series. The driller's log is as below:

No.	Drillers' Log.	Feet.	Inches.	Feet.	Inches.
	Recent and Pleistocene.				
1	Surface material	13		13	
	Coal Measures—Pennsylvanian.				
2	Soft blue shale	7	6	20	6
3	Sandstone	9	6	30	
4	Blue shale	9	6	39	6
5	Coal		10	40	4
6	Fire clay	3		43	4
7	Sandstone	19	8	63	
8	Blue shale	15		.....	
9	Blue shale	51	6	129	6
10	Sandstone	10	6	.....	
11	Sandstone	23		163	
12	Blue sand shale	15		.....	
13	Blue sand shale	30		208	
14	Blue shale	39		.....	
15	Blue shale	23	6	270	6
16	Coal	1	2	271	8
17	Blue shale	1		272	8
18	Limestone	10		282	8
19	Blue shale	17	4	.....	
20	Dark shale	5	5	.....	
21	Blue shale	1		306	5
22	Lime rock	1		307	5
23	Black shale	3	7	311	
24	Blue shale	19		.....	
25	Blue shale	30		350	
26	Sandstone	8		.....	
27	Sandstone	35		.....	
28	Sandstone	23	6	426	6
29	Limestone	5	6	.....	
30	Limestone	6		438	
31	Black slate	3		.....	
32	Black slate	3		444	
33	Blue sand shale	10		454	3
34	Coal		3	454	3
35	Fire clay	3		457	3
36	Blue shale	1		458	3
37	Sand shale with hard band	20		.....	
38	Sand shale with hard band	13		491	3
39	Sand shale	12		.....	
40	Sand shale	10		.....	
41	Sand shale	20		.....	
42	Sand shale	27		560	3
43	Blue shale	12		.....	
44	Blue shale	20		592	3
45	Light sand shale	11		603	3
46	Coal	1	4	609	7
47	Light sand shale	7		.....	
48	Sand shale	20		631	7
49	Light shale	8		.....	
50	Blue shale	6	8	646	3
51	Limestone	2		648	3
52	Light shale	4		652	3
53	Sandstone	10		.....	
54	Sandstone	7		669	3
55	Black shale	2	6	671	9
56	Coal		6	672	3
57	Light shale, soft	10		682	3
58	Limestone	1		683	3
59	Sandstone	3		686	3
60	Sandstone	12		.....	

No.	Drillers' Log.	Feet.	Inches.	Feet.	Inches.
61	Sandstone	15		.....	
62	Sandstone	30		743	3
63	Sand shale	6		749	3
64	Blue shale	10		.....	
65	Blue shale	29		788	3
66	Black slate	2		790	3
67	Coal		6	790	3
68	Sandstone	4		794	9
69	Limestone	1	8	.....	
70	Soft limestone	3		799	5
71	Black slate	1		800	5
72	Coal	1		801	5
73	Fire clay	2		803	5
74	Light shale	7	11	811	4
75	Limestone	8		819	4
76	Black slate	2		.....	
77	Light slate	10		.....	
78	Light slate	8		.....	
79	Blue slate	5		844	4
80	Coal	2		846	4
81	Sand shale	5		.....	
82	Sand shale	17		868	4
83	Limestone	3		.....	
84	Limestone	3		874	4
85	Blue shale	2		876	4
86	Sand shale	12	6	888	10
87	Sand shale	2		907	4
88	Sand shale	16	6	.....	
89	Soft black shale		6	.....	
90	Dark blue shale	2		909	10
91	Blue limestone	4		913	10
92	Coal limestone	5	3	919	1
93	Fire clay		9	919	10

The State Geological Survey was fortunate in procuring not only the log of the Delafield well, but also the complete core as it was taken out by the drillers. For this the Survey is greatly indebted to the Delafield Coal Company, and especially to Messrs. F. J. Goehring and W. J. Goin. The writer made an examination of this core, and the following notes may prove useful to persons interested in this boring or to geologists who may in the future study this region:

Number 1. Absent in the core.

Number 2. A coarse gray sandy shale, with partings following oblique bedding planes. Scattered along some bedding planes throughout are small fragments of plant remains.

Number 3. A micaceous arenite of fine texture, slightly argillaceous, with imbedded small fragments of plant tissues. Below this there is about three feet of gray medium grained micaceous sandstone. Nearly one-half of the mica is biotite. Ripple marks are indicated on the surfaces of the broken core.

Number 4. The uppermost five feet is a light gray calcareous clay shale. This is followed by a foot of black, very fine grained and slightly micaceous shale, in which some plant remains were noticed. The next two feet consists of highly calcareous shale, or "miner's clod." A great number of fossils were observed and the following recognized: *Orbiculoidea missouriensis, Pugnax rockymontanus, Seminula argentea,* crinoid stems and fragmentary shells too imperfect for identification either brachiopods or pelecypods. Directly over the underlying

coal is a black shale, about two feet thick. A *Seminula argentea* and several crinoid stems were noticed in this shale.

Number 5. Coal, about ten inches.

Number 6. A gray argillite that disintegrates when exposed, breaking into irregular small chips.

Number 7. The upper four feet is a bluish gray shale. Then a sandy micaceous shale about three feet, containing an abundance of fragments of plants. The lowest part is a light gray and coarse grained sandstone.

Numbers 8 and 9. A gray argillaceous shale of fine texture. The lowest two or three feet are more sandy and micaceous than the upper part of this section of the core. The cleavage planes indicate ripple marks. Some plant impressions were noticed.

Numbers 10 and 11. The greater part of the core of these numbers is a coarse grained sandstone, with interstitial calcareous cement In two places it was seen to be highly calcareous. There are occasional small pockets of calcareous material in the sand and small worn fragments of shells. Where the calcareous ingredient is the least a number of fragments of plant remains were noticed. Carbonaceous material appears along some bedding seams and also in clusters, which gives the rock a blotchy appearance. Biotite was noted with the muscovite. The lower four feet are not as calcareous as the upper portion.

Numbers 12, 13, 14 and 15. This is a gray shale, slightly variable in its character. The upper fifty-five feet is a dark micaceous shale, having in it scattered fragments of plant remains. The next five feet are slightly calcareous and two fossils were noted. This is more compact than the preceding. The next forty-five feet is a dark, fine-grained argillaceous shale. Directly above the coal below these numbers is about a foot of a mottled shale, which on weathering effloresces, probably owing to the presence of much iron pyrites.

Number 16. Coal. One foot and six inches.

Number 17. A highly calcareous bluish gray shale, with an abundance of small fragments of fossils and streaks of compact yellow limestone. Tests of ostracoids, crinoid stems, *Aviculopecten* (?) sp., *Nucula ventricosa, Pleuro tomaria* (?) sp., noted.

Number 18. About six feet of gray shale, compact and fine grained. Below this is a sandy blue shale, somewhat coarser and about four feet thick.

Number 19. The first two feet is a lumpy mixture of calcareous material and dark clay. The calcareous material is in a concretionary condition. Then there are two feet of blue calcareous shale. The next thirteen feet consist of gray argillaceous shale. The last five feet are more sandy than the shale above.

Numbers 20 and 21. The first six inches is a limestone, with *Lingula umbonata* in great abundance. This is followed by four feet of shale containing numerous Lingulas. Then there is about one foot of impure dark limestone, which contains frequent joints of crinoid stems and undetermined brachiopods and pelecypods. There are some particles of a bright green mineral and also mica. The lowest foot is a black, very fine grained shale.

Number 22. A dark impure limestone, with an abundance of crinoid stems, pyrites and occasional scales of mica. A minute scale of a ganoid fish was noted.

Number 23. The upper foot and a half is a dark shale that has an abundance of plant remains. This shale was submitted to Dr. David White of the U .S. Geological Survey for examination. He offers the following comments:

"By breaking up the rock I find associated wit the Neuropteris (1) a single fragment of a small Pecopteris, having thick, villius, narrow and basally constricted pinnules similar to those of *P. Strongii*; (2) a minute piece of a small, thick, round-lobed Sphenopteris, probably belonging to the *Mixta* group; (3) a portion of a single intercostal segment of a Trigonocarpus, perhaps identical with *T. starkianum;* (4) a very small sporgangium, probably lepodophytic; (5) numerous minute megaspores scattered through the black shale; (6) slender rods of dark, jetty coal, possibly the residual of macerated resin vessels; (7) several small imperfect remains of fish scales.

The pinnules of *Neuropteris Scheuchzeri* are of good size and development. The species is the most omnipresent and long continued of the Upper Carboniferous filicoid types, and the form here represented ranges from near the base of the Allegheny to the vicinity of the Pittsburg coal, which constitutes the base of the Monongahela formation in the Appalachian trough.

Fish scales similar to the fragments here present occur, I believe, in the roofs of both No. 5 and No. 6 of the Illinois coal and may, of course, also be found at other horizons."

The next six inches is a calcareous shale containing fossils, such as *Pugnax sp., Orbiculoidea nitida, Seminula argentea.* Then a foot of very fine grained black, stiff and slaty shale. Below this are three inches of black calcareous shale, with fragments of shells and impressions of leaves. Below this are three inches of black non-calcareous shale. Lastly, there are about two inches of calcareous, micaceous shale containing *Pugnax sp., Orbiculoidea missouriensis, Seminula argentea, Ambocelia planoconvexa.*

Numbers 24 and 25. A gray argillaceous shale. In places it is some what sandy and micaceous. At about twenty-five feet from top there is a small seam of sandstone, about six inches thick. Another sandstone about as thick occurs six feet farther down.

Numbers 26, 27 and 28. The first ten feet consists of a series of alternating sandstones and shales. The rest is a coarse grained, gray sandstone, gritty and micaceous. Impressions of plants noted.

Numbers 29 and 30. The first foot consists of light gray, very compact limestone. *Productus longispinusa.* Fistulipora, crinoid stems, and bryozoans noted. Below this there is four feet of coarse sandstone. This has scattered lumps of shaly and calcareous materials imbedded. Following this is an impure limestone, with concretionary lumps of clay-iron-stone. The limestone contains many fragments of fossils, such as crinoid stems, *Derbya crassa,* and bryozoans. Throughout the mass the are minute crystals of iron pyrites. Then there follows about a foot of black shale, in which are seen occasional faint impressions of plants and numerous "fucoidal" markings, which have the appearance of traversions, due to borings by worm-like animals. These more or less follow the directions of the bedding planes and measure about one-tenth of an inch in width and run in curves across half the thickness of the core. Lastly, there is about one and a half feet

of limestone. This is very compact and shows *Reticularia perplexa, Seminula argentea,* fragments of various fossils, such as spines of brachiopods and pieces of small shells. Some of the bedding planes in this limestone are marked by minute joints impregnated with carbonaceous material.

Numbers 31 and 32. A black, fine-grained, slaty shale.

Number 33. A fine-grained, compact, dark and sandy shale. The lowest two feet contained *Lingula umbonata, Myalina(?) sp.* and an undetermined pelecypod, and had thin scattered partings filled with pyrites. There are also some very thin seams of coaly material, bending and oriented in various directions.

Number 34. Coal. Three inches.

Number 35. A siliceous mottled clay, with occasional thin streaks of coal. The mass breaks into fragments along numerous small slickensided joints.

Numbers 36 to 45. The first ten feet consists of blue, hard shale. The remainder is principally a shale that varies in texture. The last fifteen feet are decidedly more sandy than any of that above it. The lowest part of this core is broken into small angular fragments as if cut by numerous joints.

Number 46. Coal; one foot four inches.

Numbers 47 to 52. Beneath this coal is a calcareous shale with indistinct bedding. This contains *Astartella sp., Pleurotomaria speciosa, Bellerophon percarinatus(?)* small species, *Soleniscus brevis,* two species of pelecypods too fragmentary for identification and an undetermined gastropod. The next is a dark shale. About eighteen feet from the coal is four feet of this material, which contains a large number of plant remains. This also was submitted to Dr. David White, who reports as follows:

"The matrix labeled '47-52' consists of a somewhat coarser gray rock, including small particles and abraded fragments, which have evidently suffered somewhat from maceration or transportation, the greater amount consisting simply of 'Hachsel.' The specimens contain two fragments of a Pecopteris with thick midrib and numerous open nerves, somewhat suggestive of the villosa type, though of a facies generally later than that species. The aspect of these fragments which, I regret to say, are not specifically determinable, suggests some of the forms found in the Conemaugh, and the upper portion of the Alleghany formation. In addition to the Pecopteris, the collection contains a portion of a single verticil of *Annularia stellata* and a piece of a rootlet belonging probably to *Stigmaria verrucosa.*"

Numbers 53 and 54. A cream colored, moderately coarse grained and sharp sandstone, with seams of shale varying from one-half to six inches in thickness. The sandstone shows carbonaceous partings and contains considerable mica.

Number 55. A black bituminous shale, containing plant remains. This shale was submitted to Dr. David White of the U. S. Geological Survey for the examination of plant remains. He submits the following comments:

I have examined the portion of drill core from Delafield, Illinois, and have carefully split up the rock fragments in order to bring to light as many forms as possible.

The shale, at a depth of 671 feet, contains large numbers of leaves and stems of Cordaites. These monopolize the bed, and the core reveals a disappointingly small number of additional forms, which naturally are represented only by very small fragments. The following species are present:

Pecopteris cf. *tenuinervis* Font. & I. C. White.
Neuropteris Scheuchzeri Hoff.
Calamostachys stellata Schlotheim sp.
Sigillaria obliqua? Brongn.
Artisia transversa Presal.
Cordaites Mansfieldii Lesq.? (Fragments too small for exact determination.)
Cordianthus sp. (Very small form.)
Cordiacarpon sp. Indeterminable.

Of the species last enumerated a portion only of one specimen is at hand, the perphery of the boring having excluded the greater part of the seed. The shale contains numbers of a small megaspore, probably belonging to some Calamarian type.

I regret having to state that the flora contains little that is of restricting stratigraphical value and I am consequently unable to offer any conclusion of importance as to the coal horizon represented by this fragment of the core. However, from the grouping of the species and the facies represented by two of the forms, I am disposed to believe the horizon to be somewhat higher than coal No. 6, of the Illinois series. The Pecopteris form represents a condition of development that is generally characteristic of the higher coal measures (Upper Conemaugh and Monongahela) of the Appalachian basin. As you know, we have no adequate collections representing either the vertical or horizontal distribution of the species in the Illinois coal field for the comparison of isolated local floras. Hence, any attempt to refer any given flora to its proper horizon, especially if that horizon belongs above the level of coal No. 2, is both difficult and hazardous.

Number 56. Coal.

Number 57. Dark sand and micaceous shales in which there is an abundance of fragments of plant remains. Some of the mica is biotite.

Number 58. A highly calcareous shale (or miner's "clod") with a profusion of fragments of fossils, among which were noted a pygidium of a trilobite, *Lophophyllum proliferum,* crinoid stems, *Chonetes glaber(?), Derbya crassa, Seminula argentea(?), Nucula beyrichi(?), Pleurotomaria speciosa(?), Orbiculoidea missouriensis, Pugnax uta.*

Number 59. A gray sandy shale, with some indistinct impressions of leaves and roots of plants.

Numbers 60, 61 and 62. A series of coarse grained sandstones and shales. The sandstone is light brown in color, very micaceous and shows ripple marks and thin partings of carbonaceous materials.

Numbers 63, 64 and 65. The upper six feet approaches a fine sandstone and the lower part is a gray shale.

The core* between numbers 66 and 79, representing a thickness of fifty-six feet, was in such a condition that none of it could be checked with that of the driller's log. But within this depth there was about twelve feet of dark gray clay or shale that contained a great profusion of small spheroidal concretions of a yellow material with radiate structure. This does not effervesce with acid and is harder than gypsum.

* The boxes in which the lowest part of the core was shipped, extending from No. 66 to 93, had been disarranged in transportation, making it impossible to check this part of the core with the records as given by the drillers. Such facts as it has been possible to ascertain, relating to this part of the core, are as given.

The material representing numbers 80 to 93, though somewhat disarranged, was in a better condition and checked fairly well with the driller's log.

Number 80, representing two feet of coal, was wanting.

Numbers 81 and 82 was a shale, which on weathering disintegrates very rapidly into a fine powder. It is in places somewhat bituminous. In color it varies from a dark gray to black. The texture is fine and there is no effervescence with acids. Thickness of this material about five feet.

Below this is a shaly limestone, which is concretionary in texture and unevenly bedded. The argillaceous ingredient is higher in some parts than others. The thickness of this shaly limestone is about five feet, and probably represents numbers 83 and 84.

Materials representing numbers 85 and 86 were not seen. According to some notes furnished to the Survey, the lowest part of the core which was secured probably represents numbers 89 and 90. It is a soft dark gray shale, with dark and light colored bands. It is very fine grained and is an argillaceous shale. The lower two feet of this shale is more compact and decidedly calcareous. In this lower part there were noted single specimens of *Chonetes mesolobus, Seminula argentea* and a fragment of a crinoid stem. Total thickness, about thirteen feet.

Number 91. Limestone wanting.

Number 92. Coal, five feet three inches. Retained by Delafield Coal Company.

Number 93. Fire clay, wanting.

THE ELM GROVE COAL COMPANY'S BORING.

The Elm Grove Coal Company's prospect hole is located on Dally's farm, three miles north of McLeansboro, in section 27, Crouch township. This hole is 1,294 feet deep. The log has been kindly furnished by Mr. J. E. Rawls and is as follows:

No.	Drillers' Log.	Feet.	Inches.	Feet.	Inches.
	Recent and Pleistocene.				
1	Surface	1		1	
2	Light clay	6		7	
3	Hard pan	7		14	
	Coal Measures—Pennsylvanian.				
4	Shale, blue and black	19		33	
5	Coal		3	33	3
6	Light shale	1	3		
7	Sand shale	17	6	52	
8	Coal	1	7	53	
9	Fire clay	2	5	56	
10	Sandstone	38	6	94	6
11	Coal	1	9	96	3
12	Light shale	2	9	99	
13	Sandstone	39		138	
14	Sand shale	64		202	
15	Blue shale	33		295	
17	Coal	1	6	296	5

No.	Drillers' Log.	Feet.	Inches.	Feet.	Inches.
18	Fire clay		1 6	298	
19	Light shale	10		308	
20	Sand shale	110		418	
21	Limestone	4		422	
22	Sand shale	40		462	
23	Blue shale	39		501	
24	Sandstone	3		504	
25	Sand shale	82		586	
26	Blue shale	16		602	
27	Limestone	2		604	
28	Light shale	8		612	
29	Black slate	4		616	
30	Sand shale	79		695	
31	Light shale	7		702	
32	Light sandstone	30		732	
33	Limestone	4		736	
34	Light shale	2		738	
35	Sand shale	16		754	
36	Sandstone	107		861	
37	Blue shale	24		885	
38	Coal		6	885	6
39	Fire clay	4		889	6
40	Sand shale	69	6	959	
41	Sandstone	4		963	
42	Black slate	1		964	
43	Sand shale	4		968	
44	Green shale	4		972	
45	Limestone	4		975	
46	Sand shale	8		984	
47	Sandstone	12		996	
48	Sand shale	17	6	1013	6
49	Limestone	5	6	1019	
50	Coal	7	6	1027	6
51	Fire clay	1	2	1028	8
52	Sand shale	7	4	1036	
53	Sandstone	16		1052	
54	Sandstone	12		1064	
55	Coal	1	2	1065	2
56	Sandstone	18	10	1084	
57	Blue shale	13		1097	
58	Coal	5	1	1102	1
59	Fire clay	11	11	1103	
60	Sandstone	14	11	1117	
61	Sand shale	6		1123	
62	Sandstone	9		1132	
63	Sand shale	43		1175	
64	Sandstone	7		1182	
65	Limestone	3		1185	
66	Black shale	3		1188	
67	Sandstone	9		1197	
68	Black shale	3		1200	
69	Limestone	2		1202	
70	Sandstone	44		1246	
71	Sand shale	15		1261	
72	Sandstone	33		1294	

The author's thanks are due to Dr. David White of the U. S. Geological Survey, who has examined and reported on the paleo-botanical specimens, and to Dr. Stuart Weller of Chicago University, who has examined the fossil invertebrates. The State Geological Survey is under obligations to Mr. A. W. Lewis, who was instrumental in procuring the Delafield log and core. At present our knowledge of the stratigraphy of this region hardly warrants any attempt at correlating these records with the general section made out by Professor A. H. Worthen from a study of outcrops.

STRATIGRAPHIC WORK IN THE VICINITY OF EAST ST. LOUIS.

(By N. M. Fenneman.)

Contents.

Introduction.

Between June 20 and Sept. 20, 1906, a scientific and economic survey was made of that part of Illinois which is comprised within the East St. Louis quadrangle. By a coöperative arrangement with the United States Geological Survey, that part of the quadrangle which lies west of the Mississippi river, together with the St. Louis quadrangle, were included in the same survey. This entire area is a rectangle thirty-one miles long, east and west, and seventeen and one-fourth miles wide, north and south, having the city of St. Louis at its center, the northeast corner of the rectangle being about six miles south of Edwardsville and the southeast corner one mile south of Belleville. Of the total area of 535 square miles, 200 lie within the State of Illinois. Some work of a less detailed kind was done outside the boundaries of this area. A report on the entire area, including detailed geologic, structural and economic maps, will be published by the United States Geological Survey. An educational and scientific bulletin pertaining primarily to the Mississippi river and the area on the east side will be published by the State Geological Survey.

Physiography.

The Mississippi trough.—Of the 200 square miles in Illinois, the larger part is on the flood plain of the Mississippi, which here lies almost wholly on the east side of the river and has a width varying

from three to ten miles, with an altitude for the most part between 400 and 420 feet above sea level. This area, with its northward extension to Alton, is the so-called American bottoms. A large part of it is subject to overflow, but the fertility of its farm lands has for half a century made its reclamation a subject of study. In more recent years the demand for railroad yards and manufacturing sites have caused the rapid growth of East St. Louis and other smaller cities, the protection of which from floods adds incentive to the reclamation of the bottom lands.

The flood plain lies in a great trough, which continues to be cut in the solid rock by the downward scour and lateral shifting of the river itself. The nearly horizontal strata which once filled the trough are now seen in the fine rock scarps which at many places overlook the river. The bottom of the trough is, in general, from fifty to 100 feet below the river's surface; being, at ordinary stages of the river, covered by from thirty to eighty feet of gravel and sand. The meagre data derived from deep borings on the flood plain seem to indicate that eastward from the river channel, the depth to bed rock becomes somewhat greater, being everywhere overlain by gravel and sand such as are found beneath the present river. In other words, the river is not now following the deepest line or axis of its rock trough.

The Uplands.—East of the flood plain, and rising from 150 to 200 feet above it, is an upland which is fairly typical of a large part of western Illinois. The surface is cut by many small and often steep sided valleys. The intervening ridges or tablelands are rarely more than a fraction of a mile in width, but since all of these rise approximately to the same height, the valleys are not observed except in the immediate foreground, and to a distant view the country appears level. This upland is separated from the plain below by an abrupt bluff, which, for some miles south of Stolle, is in the main a vertical cliff of limestone. Similar rock scarps appear on the Missouri side, marked by a line of quarries opposite Arsenal Island. The uplands west of the river are similar in general character and height to those on the east side, though for some distance along the river front of St. Louis the slope to the water level is less abrupt than that of the Illinois bluffs.

A striking characteristic of the bluff south of Stolle (as at many places in and around St. Louis) is a phenomenal development of sinkholes, through which the surface water is conveyed downward to passages in the limestone. In a few cases these passages are fair sized caves. "Falling Spring," which issues from the vertical cliff near the southern border of the area, represents an underground stream of considerable size.

Stratigraphy.

Sections.—The solid rocks exposed in the bluffs are Lower Carboniferous, or Mississippian, and Coal Measures, or Pennsylvanian. The latter are also exposed in a number of coal mines. The best section obtained is from a deep well near Monk's Mound, six miles northeast of East St. Louis. Of the strata here named, the Spergen and St.

Louis are well exposed in the bluffs farther south, the higher beds being too soft to make cliffs; the lower being, in this vicinity, beneath the level of the flood plain. All the strata here named outcrop along the Mississippi river a few miles to the south and along the Meramec river, in the southwest corner of the St. Louis quadrangle, or a few miles farther west.

Well Section at Monk's Mound.

	Thickness Feet.	Depth Feet.
Pleistocene and Recent—		
Alluvial deposits, mainly coarse gravel and sand	150	150
Coal Measures—		
Blue shales or clay with subordinate beds of gray limestone	85	165
Fine gray sandstone with a thin light colored limestone near base. Age doubtful	80	735
Lower Carboniferous—		
St. Louis limestone; the upper part characterized by layers of light color and fine texture. Chert and ferruginous stains are most frequent in the lower part	365	
Spergen limestone; light colored and containing a little shale	38	
Warsaw; blue or slate colored calcareous shale	62	
Osage; gray to white limestone with an abundance of white chert	235	
Fern Glen (Kinderhook): mainly pink calcareous shale, but including at the base 5 feet of greenish limestone containing crinoid stems	35	1050
Devonian (?) to Ordovician, inclusive—		
Green calcareous clay	2	
Limestone, generally gray or pink, containing many well-rounded sand grains	43	
Dark blue clay or shale	40	
Limestone of various shades, occasionally pink; somewhat gritty near top	200	
Greenish gray shale passing down into argillaceous limestone	155	
Limestone of various shades	485	
St. Peter sandstone: pure quartz sand with large well-rounded grains	125	

Higher beds of the Coal Measures are preserved in the uplands east of the bluff. The upper part of the section there is, in general, as follows:

General Section near Belleville.

	Feet.
Loess and glacial drift	80
Coal Measures, chiefly shale and limestone with subordinate sandstone and coal. The age of a 75-foot sandstone at the base being in doubt	370
Lower Carboniferous—	

Drift.—Aside from the flood plain, the entire area is covered by loess to a depth varying from a few feet to perhaps fifty feet. Thicknesses greater than ten or fifteen feet are for the most part confined to the immediate vicinity of the bluffs. The excessive thickness of the loess at the summit of the east bluff causes at places a pronounced slope eastward, or toward the upland. This strongly suggests that the loess thus rising above the general level was carried to its present position by winds and was in large part derived from the immediate valley of the river. The same phenomenon is strikingly apparent on the east side of the Missouri river opposite St. Charles. The base of the loess is at many places coarse and gravelly. Beneath the loess on the Illinois side the till of the Illinoian drift sheet is exposed in certain small valleys.

Structure.

The area here considered lies on the northeast side of the Ozark uplift. To this relation is due not only the general northeasterly dip of the rocks within the area, but probably also the thickening of the several strata to the northeast, suggesting that during the deposition of at least a part of those sediments there was land to the southwest. The general dip is seen in going west along the Meramec river or south along the Mississippi, in either of which cases successively older strata are encountered until in either case at a distance of about twenty-five miles the St. Peter sandstone comes to the surface, though it is more than 1,500 feet below the city of St. Louis.

Both the general dip and the thickening of the strata appear from a comparison of three deep wells lying almost in a straight line whose direction is east-northeast. These wells are (1) the one at the insane asylum, six miles west-southwest of the Eads bridge; (2) the Belcher well, near the Eads bridge; and (3) the well drilled for oil near Monk's Mound, seven miles east-northeast of the bridge.

Depths (below sea level) of Fern Glen Shales and St. Peter Sandstone.

	Asylum Well Feet.	Belcher Well Feet.	Monk's Mound Well Feet.
Fern Glen shales	300	210	565
St. Peter sandstone	862	1,085	1,525
Interval	662	875	960

The regional dip to the northeast is interrupted by minor wrinkles whose axes have a northwest-southeast direction. One very shallow structural trough of this kind, extending southeast from Forest Park, St. Louis, is of special interest because within it the lowest beds of the Coal Measures containing the well known Cheltenham fire clays have been preserved from erosion. Parallel with this trough and several miles east of it is a small pitching anticline, at the northwest end of which at least three deep wells have encountered considerable pockets of natural gas.

Economic Products.

The mineral products of this area which are important economically are coal, limestone, clays and moulders' sand.

Coal is now mined chiefly in the vicinities of Belleville and Collinsville, at the eastern edge of the area, though many abandoned openings appear in the Illinois bluff from Caseyville to Prairie du Pont Creek. Most of the mining is in the so-called Belleville, or "Blue Band," seam, which is from 125 to 150 feet deep at Belleville, but deepens toward the north. Its thickness is from five to seven feet. On the St. Louis side no mines are now being worked for coal, though thin coal seams encountered in fire clay mines are sometimes taken out and used.

Large quarries are opened in the bluff between Stolle and Falling Spring, as well as at numerous places in and about St. Louis. The stone taken out is in all cases the St. Louis limestone. A small portion of the output is building stone for superstructures; a much larger amount is used for foundations, curbing, etc., while a very large proportion is used as road material. An important industry is the manufacture of whiting, for which the light colored pure dense beds of the St. Louis limestone are especially fitted.

The mining of fireclay and the manufacture of clay products have not been developed on the east side of the river, though these are among the most important industries of St. Louis. The clay there used is found in a seam from three to twelve feet thick, at the base of the Coal Measures, or separated from the underlying St. Louis limestone by a very few feet of sandstone.

Large quantities of moulders' sand are obtained from this area as well as from the vicinity of Alton, mainly from the loess of the Illinois bluffs. Most of this sand is of a medium grade of coarseness and is much used as a general purpose sand for castings larger than stove plate. Specimens of coarser moulders' sand of supposedly high grade have also been taken from the terraces of the River des Peres, in the southern part of St. Louis.

NOTES ON THE GEOLOGY OF SOUTHERN CALHOUN COUNTY.

(By STUART WELLER.)

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Introduction.

Location.—In the early part of August, 1906, a reconnaissance trip from Grafton to Hamburg, via Brussels and Bachtown, was made by the writer in company with Mr. H. B. Fox of the Survey, returning via Hardin and the Illinois river valley. Later, during September, the writer, in company with several students, spent the greater portion of four weeks in that part of the county lying south of Bachtown. The geologic observations recorded in the following pages were made during these two visits to the region.

Calhoun county is an irregularly triangular area on the western border of the State, lying between the Mississippi and Illinois rivers. The total length of the county is about thirty-eight miles; the breadth in its southern half is less than six miles, except for a short distance west of Grafton, where it reaches a width of about twelve miles; in its northern half the width increases gradually to about sixteen miles at the northern boundary. The village of Bachtown lies about eleven miles from the southernmost extremity of the county, and it is to the region south of Bachtown that the following observations for the most part apply.

Structure.—Extending across the region from Dogtown Landing, a little over one mile south of West Point, is a great fault, having a general direction of about E. 5° S. This fault continues across the Illinois river bottom, and is shown as a monoclinal fold in the southwestern corner of the bluffs in Jersey county, the fold passing again into a fault about three miles farther east. By reason of this disturbance a large number of geological formations are brought to the surface in a comparatively small area, and the geologic section afforded is of especial interest for comparison with the similar sections in the northern and southern portions of the State.

The upthrow side of the fault is to the north, the oldest strata exposed being the "Lower Magnesian Limestone." The upthrow is considerably greater at the western border of the region along the Mississippi river than farther to the east, so that the dip of the upthrown strata is gently to the northeast. South of the fault line the beds are essentially horizontal except for a narrow area adjacent to the fault, where they dip steeply to the south, the beds along this line having been dragged upward with the upward movement of the rocks to the north.

The St. Louis limestone appears in horizontal beds south of the fault at the Mississippi river. North of the fault the lower beds of the St. Peters sandstone occupy the same horizontal position. The throw at this point, then, is equivalent to the total thickness of the strata between the base of the St. Peters sandsone and the St. Louis limestone; approximately 720 feet. One and one-half miles east of the river the throw is considerably reduced, the Niagara limestone on the upthrow side of the fault being at the same elevation as the St. Louis limestone on the downthrow side, giving a throw at this point of about 280 feet.

A few rods south of the major fault line upon the bank of the Mississippi river there is a decided change in both the dip and the strike of the upturned beds at the horizon where the shaly beds of the Warsaw formation should be exposed. This line marks the position of a minor fault which converges with the main fault line to the east, and probably joins it about one and one-half or two miles from the river. The rocks occupying the triangular area between these two fault lines seem to constitute a great block broken off from the main mass at this point of maximum throw of the fault, which has been crowded upward and so turned as to bring the strata into a nearly vertical position.

Along the river bank north of the fault line the St. Peters sandstone beds dip gently towards the fault for a short distance, this dip representing the down-drag in the same manner that the dip of the beds south of the fault represent the up-drag due to the faulting. Between Dogtown and West Point the sandstone beds exposed in the river bluff are thrown into slight synclines and anticlines with axes subparallel with the fault. These folds, however, are not of sufficient strength to be recognized in the strata at any distance from the river.

Stratigraphy.

The formations exposed in the region range in age from the Lower Magnesian limestone to the Coal Measures.

Ordovician.

Lower Magnesian limestone.—This formation is exposed along base of the bluff about one-fourth mile above the mouth of Dogtown creek. Only three or four feet in thickness can be seen, and even this is exposed for only a few rods. The entire outcrop is doubtless covered at high water. The rock is a gray or brownish buff, earthy, magnesian limestone, not different in any respect from many occurrences of the same formation elsewhere.

St. Peters sandstone.—The St. Peters sandstone forms the Cap au Grés bluff, which rises abruptly from the waters of the Mississippi river through much of the distance of one mile between West Point and Dogtown. The outcrop occupies only a narrow strip along the river and is about 150 feet in thickness. The rock is a massive, more or less friable, cross-beded sandstone of light color, in every respect typical of the same formation as elsewhere exposed in the Mississippi

valley. Fossils do not occur in the formation, but the correctness of the correlation of the beds is assured by their stratigraphic relations, as well as lithologic characters.

*Joachim limestone.**—This formation consists of brown or buff, more or less earthy, magnesian limestones in beds from a few inches to a foot or more in thickness, with an occasional shaly bed. It is the formation which has usually been designated as the "First Magnesian Limestone" by the older geologists of the Mississippi valley region. In the area under discussion the formation is exposed in a narrow belt lying just east of the St. Peters sandstone, and it attains a thickness of approximately seventy-five feet. Just above West Point Landing a large quarry has been opened, in which fifty feet or more of the upper beds of this formation are finely exposed, the higher part of the quarry being in the overlying Plattin limestone.

The known fauna of the Joachim limestone in Calhoun county is limited to one or more species of Ostracodes and one or two species of trilobites. The Ostracodes can usually be detected by careful collecting in any of the beds in at least the upper third of the formation and occasional layers are present where they occur in vast numbers. The trilobites are much less common and have been observed in but a single bed near the summit of the formation east of Dogtown.

Plattin limestone.†—Succeeding the magnesian Joachim limestone and lying immediately east of it there is a purer, gray or drab colored limestone formation about 100 feet in thickness, consisting for the most part of fine-grained, hard, close textured beds, often almost lithographic in appearance, with a distinctly conchoidal fracture. The beds are usually from a few inches to a foot or more in thickness and sometimes contain a considerable amount of chert. The lower beds of the formation indicate a gradual change in the character of the sediments from that now forming the subjacent formation. The complete transition occupies a thickness of about five feet.

In the basal fifteen feet of the formation fossils occur abundantly, some of these beds being made up almost exclusively of the remains of brachiopods belonging to the genera *Rafinesquina* and *Strophomena*, while other beds contain qauntities of trilobite remains of the genera *Isotelus* and *Illaenus*. Above these highly fossiliferous beds at the base of the formation, fossils become much less abundant, although careful collecting discloses them at most horizons, and an occasional bed occurs in which they are more or less abundant. In the uppermost twenty feet of the formation fossils again become abundant, some beds being literally filled with the shells of *Dalmanella subaequata*.

Kimmswick limestone.‡—The lithologic characters of the Kimmswick limestone, which lies next above the Plattin limestone and occupies the area immediately east of it, are in sharp contrast with those of the subjacent formation. This formation is a more or less coarsely crystalline, highly fossiliferous limestone, light colored when freshly broken, often nearly white or sometimes almost flesh colored. When

* Winslow, Geol. Surv. Missouri, Vol. VI, pp. 331 and 352; Ulrich, Mo. Bureau Geol. and Mines, Vol. II, 2nd ser. p. 111.

† Ulrich, Mo. Bureau Geol. and Mines, Vol. II, 2nd ser., p. 111.

‡ Ulrich, loc. cit.

seen resting upon the subjacent formation the line of contact is often sharp, though at times the transition from the lower formation to the upper occupies a foot or two in thickness. The maximum thickness of the bed observed in the region is about fifty feet at the large "cave spring" on Madison creek, between West Point and Batchtown. In both its lithologic and faunal characters the Kimmswick limestone in Calhoun county agrees closely with the typical exposures of the formation near Kimmswick, in Jefferson county, Missouri, from which locality the formation was named by Ulrich. The formation is a western equivalent of the Trenton limestone of New York, but it differs profoundly from that formation lithologically, and is also different faunally.

The fauna of the Kimmswick limestone is a large one, the trilobites and brachiopods being the most conspicuous forms, and the fossils often occur in a beautiful condition of preservation. Near the summit of the formation, as seen in the Madison creek section, there are many individuals of a large *Receptaculites,* probably *R. oweni.* In Jefferson county, Missouri, this conspicuous fossil also occurs abundantly in the upper portion of the same formation, so abundantly, in fact, that the older geologists who studied the region designated the formation as the "Receptaculite limestone."*

Post-Kimmswick unconformity.—The actutal contact of the superjacent beds upon the Kimmswick limestone has been observed at only one locality, on Madison creek. At this point the upper surface of the Kimmswick limestone is seen to be very irregular, and lying upon it is a six to ten inch bed of dark-red, residuary clay, imbedded in which are numerous residuary cherts. These cherts are fossiliferous, but their contained fauna has not yet been determined. On top of this residuary clay lies the Maquoketa shale with an intervening layer perhaps one inch in thickness, which contains large numbers of black phosphatic nodules imbedded in red granular material.

The length of time represented by the unconformity marked by this residuary clay has not been determined, but if the fauna of the included cherts proves to belong to some portion of the Plattin limestone, as it seems likely that it will, then the time interval was at least long enough to allow for the erosion of the entire thickness of the Kimmswick limestone. The presence of an unconformity of this sort in the midst of the Ordovician has not generally been recognized in the Mississippi valley, although such a condition has been hinted at by Ulrich and Schuchert.† Observations further south, however, indicate the presence of a similar unconformity in Jefferson county, Missouri,‡ and in Monroe county, Illinois, and it is believed to mark an important episode in the geologic history of the region.

Maquoketa shale.—The Maquoketa shale is an important formation about 75 feet in thickness. In its lower portion it is yellowish or

* Shumard, Geol. Surv. Mo., 1855-71, pp. 265, 276, 282, plate opp. 292, 297 and 306; Broadhead Geol. Surv. Mo., 1873-74, p. 28.

† Paleozoic Seas and Barriers in Eastern North America, Rep. N. Y. State Pal. for 1901, p. 645.

‡ Mr. E. O. Ulrich first recognized the presence of this unconformity in the field, in Jefferson county, Missouri.

buff in color, and somewhat gritty in texture. Near the base there are some harder layers from one to three inches in thickness, which stand out conspicuously in outcrops of this portion of the formation. The higher beds of the formation are more argillaceous in character, and the uppermost portion is a very even-textured, green clay-shale essentially free from grit, changing to an olive-green color with weathering. At some horizons more or less continuous pyritiferous bands occur.

Unlike the formations already described, the Moquoketa shale is exposed on the eastern side of the Calhoun county divide as well as on the west. On the east it occurs beneath the Niagaran, at the foot of the bluffs north of the fault line, and perhaps continues beneath the Illinois river bottom, since the formation occurs also in the east bluffs of the valley in Jersey county.

The fauna of the Moquoketa is not large, but at the very base of the formation in the Madison creek section, in the thin phosphatic nodule bearing layer, where the shale rests upon the red residuary clay between it and the Kimmswick limestone, there are large numbers of small pelecypod shells belonging to the genera *Cleidophorus* and *Ctenodonta,* which are specifically identical with the pelecypods which occur in such large numbers in the Maquoketa shale near Dubuque, Iowa. Associated with these pelecypods are some small Orthoceratites and an occasional gastropod and brachiopod. A few specimens of the same species of pelecypods and some small inarticulate brachiopods have also been collected from the shale several feet above the base. In the green shales of the higher portion of the formation, graptolites occur more or less abundantly, sometimes being so numerous as to form thin, black seams in the shale.

SILURIAN.

Post-Maquoketa unconformity.—The unconformity of the superjacent beds upon the Maquoketa shale is far less evident than that at the base of the Maquoketa. The immediate contact of the higher beds upon the shale has been observed at but a single locality, in one of the tributaries of Madison creek known as "Jug Hollow." At this point the line separating the two formations is sharp, the lowest bed of the super-jacent formation being a bluish, earthy rock, only a few inches thick, filled with large numbers of black phosphatic pebbles. Above this phosphatic layer are from eighteen inches to two feet of thin-bedded, apparently magnesian limestone, bluish-gray to brown in color, above which the Nigaran limestone assumes its normal character for the region. About one foot from the base is a half-inch layer which contains large numbers of a small winged pelecypod shell.

At another locality in one of the tributaries of West Point creek, these basal members of the superjacent formation are exposed, although the actutal contact cannot be seen. Here from seven to ten feet of the more or less phosphatic beds may be seen. The presence of black phosphatic nodules not infrequently accompanies unconformities in the Mississippi valley region, and their occurrence at this horizon in the region under discussion, is one of the chief reasons at

present, for inferring an unconformity at the summit of the Maquoketa. It is probable, however, that a study of the Niagaran fauna of the superjacent beds, will afford additional evidence of a time break.

Niagaran limestone.—This formation is in the main a yellow or buff colored magnesian limestone, rather soft when taken from the ground, and apparently becoming harder on exposure. It is usually rather porous in texture, and is frequently much mottled with dark dendritic markings of small size. It occurs on both the east and west sides of the Calhoun county divide, north of the fault, the best exposures being in the bluffs on the eastern side of the county. The thickness of the formation varies from 30 to 80 feet in the region south of Batchtown, on account of the differential erosion of this limestone preceding the deposition of the superjacent formation.

The fauna of the Niagaran in this region is somewhat meagre, and consists for the most part of diminutive species of brachiopods, a little *Plectambonites* being perhaps the most common form.

Further north in the county, in the region of Hamburg, a very different limestone has usually been referred to the Niagara. It is a massive, nearly white limestone, from which no fossils have been secured. The true correlation of this limestone, and the determination of its relation to the buff magnesian limestone further south, must wait until an opportunity is afforded for a careful search for fossils, and for more careful field observations.

DEVONIAN.

Middle Devonian limestone.—In the section shown along the creek at the south edge of Hamburg, the Devonian limestone is represented by arenaceous, shaly beds resting unconformably upon the subjacent limestone, but passing into limestone above. The entire thickness of the formation does not exceed 4 feet. The beds at this locality contain an abundance of fossils, mostly brachiopods and corals, by means of which it may be correlated with some portion of the Middle Devonian limestone of Iowa. On the eastern side of the county the Devonian limestone is exposed in its proper stratigraphic position in the bluff at many points south of Hardin, and is usually abundantly fossiliferous. An excellent exposure may be seen in the point of the hill at Monteray school house. Eleven feet of more or less crystalline, buff, yellow or sometimes nearly white limestone are exposed here, most of the beds being highly fossiliferous, with the same fauna as that occurring at Hamburg and elsewhere in the region.

South of the village of Meppen on the east side of the county, and south of Batchtown on the west, no Devonian rocks have been detected. Although the summit of the Niagaran has been observed not infrequently in this region, the Devonian is always absent, the bed immediately above the Niagaran being the Kinderhook shale, the Devonian having been entirely eroded before the deposition of the Kinderhook.

MISSISSIPPIAN.

The Kinderhook overlap.—The Kinderhook beds throughout the region rest unconformably upon the subjacent formations, at Hamburg upon the Middle Devonian limestone, and further south upon the Niagaran. Furthermore there is clearly an overlap of the beds to the south. At Hamburg the lowest Kinderhook bed is the Louisiana limestone which has here a thickness of about four feet. To the south this formation becomes reduced in thickness to a point about three and one-half miles south of Hardin where it disappears. Beyond here the shale bed, which to the north is superjacent to the Louisiana limestone, rests upon the older rocks, at first upon the Devonian limestone and then upon the Niagaran.

Louisiana limestone.—In the Hamburg section about four feet of drab-colored, brittle limestone, with almost the texture of lithographic stone, occurs above the Devonian limestone with an intervening bed of soft green shale about one foot in thickness. This limestone is identical in its peculiar lithologic characters with the typical Louisiana limestone in Pike county, Missouri, where it attains a thickness of from 50 to 60 feet. Furthermore the fauna of the bed at Hamburg is identical with that of the same formation at Louisiana, Missouri.

On the east side of the county the same formation is exposed three and one-half miles south of Hardin, just north of the residence of Mr. John Knese. At this locality, although the thickness of the bed does not exceed one foot, it retains the typical lithologic and faunal characters of the formation. South of this point the formation is absent, the superjacent shales resting directly upon the Devonian limestone.

Kinderhook shale.—In the area south of Bachtown and for a considerable distance north of the village, the Kinderhook is represented by only two members, the lower one a shale and the upper a limestone. The Kinderhook shale is usually highly argillaceous, of uniform texture, with a bluish or greenish color. Because of its soft nature it is easily weathered, and the outcrop is usually more or less covered by debris, so that it is difficult to measure its exact thickness. At one point the interval between the highest outcrop of the Niagaran and the lowest exposure of the superadjacent limestone was found to be 73 feet, while at another point the thickness of the shale seemed to be but 25 feet. The actual average thickness of the formation doubtless lies somewhere between these two figures, and is probably not far from 40 or 50 feet.

The fauna of this Konderhook shale is always meagre, although specimens of a small *Lingula* may usually be found by careful search near the base of the formation. At Hamburg, however, where the shale overlying the Louisiana limestone are more arenaceous than further south, there is an intercalated bed of light colored oolitic limestone, varying in thickness from one-half inch to fifteen feet, which contains a large and highly interesting fauna.*

Chouteau limestone.—The conspicuous limestone superadjacent to the Kinderhook shale in the southern portion of the area, has not been recognized in the Hamburg section, but at Hardin it is exposed in the

* For a discussion of this fauna see Trans. Acad. Sci., St. Louis, Vol. XVI, No. 7, p. 465.

village and again in the high bluff north of the village. From Hardin south the formation is more or less continuously exposed in the bluff nearly to the fault line. The rock is a hard and tough, drab-colored limestone, in rather thin, knotty beds, with thin shaly partings, usually with specks of calcite scattered through the mass, but occasionally containing beds with almost a lithographic texture. The thickness of the formation is about 60 feet.

On the south side of the fault line a few feet in thickness of this limestone is exposed for a few rods along the south bank of Dogtown Creek, just west of the point where the road from Beechville to Dogtown crosses the creek. This is the oldest formation exposed south of the fault line, and it occurs in the small triangular area where the beds are upturned so as to be nearly vertical in position.

The fauna of this limestone consists of numerous species, although only occasionally do they occur in abundance. The fossils occur in the same condition of preservation, and are the same species as are known in the typical Chouteau limestone of central Missouri. The largest collection which has been made in Calhoun county, is from the exposure south of the fault line along Dogtown creek, and so nearly like the fossils from the Chouteau limestone of Cooper and Pettis counties, Missouri, both lithologically and specifically, is this material, that one perfectly familiar with the Missouri fossils would be unable to detect any difference whatever.

From north of the fault line collections have been made from various points in the ravines southeast of Batchtown, on both sides of the divide, which agree in all respects with those from the locality on Dogtown creek, and from Missouri.

Burlington limestone.—South of Bachtown and north of the fault line, the Burlington limestone is the youngest Mississippian formation present, where it occupies the summit of the divide. South of the fault line the formation occupies a narrow belt in the area where the strata are tilted to a nearly vertical position. It outcrops on the bank of the Mississippi river a few rods south of the mouth of the Dogtown creek, and again at intervals along the south side of the fault line for a mile east from the river.

The formation has its typical expression in this region, being a more or less coarsely crystalline, light colored, crinoidal limestone, with numerous chert bands at some horizons. In the lower portion there are some brownish beds such as are found elsewhere in this part of the formation. The Burlington fauna of the region contains the more characteristic species of the typical Burlington fauna, such as *Spirifer grimesi, Straparollus latus,* etc. Only a few imperfect crinoid bodies have been recognized, but they are all of species common to the formation elsewhere.

Keokuk limestone.—The Keokuk limestone is only imperfectly represented among the highly tilted starta in the narrow belt south of the fault line. The formation has been seen in only a few isolated outcrops, and is lithologically similar to the subjacent Burlington limestone, but at one locality on Dogtown creek, about one mile from the river, the beds have furnished an assemblage of fossils containing

such Keokuk species as *Spirifer suborbicularis, Palaeacis obtusus,* etc., which are quite characteristic of certain beds of the Keokuk limestone in the region of its typical development in southeastern Iowa.

Warsaw formation.—In the typical Mississippian section the Keokuk limestone is followed by a series of shales and shaly limestones, known as the Warsaw beds. In southern Calhoun county, however, this formation can scarcely be recognized. The formation is doubtless present in the region, but it has been obscured by reason of the faulting. These shaly beds have apparently furnished the line of weakness along which the secondary fault, mentioned on a previous page, occurs, allowing the triangular mass of strata, in which the Chouteau, Burlington and Keokuk formations can be detected, to be pushed up into such a position as to cover the Warsaw beds themselves. There is, however, in the outcrop along the Mississippi river bank, a small exposure of shaly beds beneath the Spergen limestone, which probably represents a portion of the Warsaw, although no fossils have been recognized.

Spergen limestone—On the Mississippi river bank, just south of the secondary fault line, a few feet of limestone is exposed which in its weathered condition is a porous, brown rock, granular in texture. The bed probably does not exceed 20 feet in thickness, although only a small portion of this is exposed at any one place.

The fossils in this bed are but poorly preserved, but specimens of *Eumetria marceyi* and a small *Straparollus* have been recognized, which are sufficient for correlating the bed with the Spergen limestone.

St. Louis limestone.—From a quarter of a mile south of the mouth of Dogtown creek to the end of the bluffs along the river to the south, above the mouth of the Illinois river, the St. Louis limestone outcrops almost continuously along the Mississippi river bank, and except for a short distance at the northern portion of the outcrop where they have been dragged upward by the faulting, the beds are essentially horizontal. The total thickness of the formation probably does not fall short of 150 feet, and may be greater. The formation consists of limestone nearly throughout, most of which is of a light gray color, with a few more or less shaly beds. The limestone is exceedingly variable in texture; some beds are dense, almost lithographic in texture, others are more or less granular or crystalline, and at least one bed of considerable thickness is a brecciated or conglomeratic layer, probably the same conglomerate layer which is so conspicuous in the bluffs north of Alton.

The topography of the area underlain by the St. Louis limestone is strongly characterized by the large number of sink-holes everywhere present, it being identical in this respect with the St. Louis limestone areas elsewhere in the Mississippi valley.

Rosiclare sandstone.—In the rim of a large sink-hole just north of the Beechville postoffice, there is exposed a highly calcareous sandstone which has been quarried for foundation stone. This rock is of a light gray or nearly white color, being identical in its lithologic characters with a bed at the summit of the section at Alton, which has been quarried nearly opposite the C. & A. R. R. station at that city. In the quarries in the river bluffs in the northern part of the city of Alton, along the C. P. & St. L. R. R., forty-four feet of this rock are ex-

posed, it being the highest bed present in the section, and at one point it has afforded an abundance of fossils. The commonest species present is a peculiar and probably undescribed Rhynchonelloid shell which also occurs in abundance in a similar sandstone in a similar stratigraphic position in Monroe county, Illinois, west of Waterloo. In the Monroe county locality this sandstone is clearly seen to be a member of the Ste. Genevieve limestone formation, and is undoubtedly a northern extension of the Rosiclare sandstone member of this formation, as it has been described in Hardin county in the southern portion of the State.*

Although no fossils have yet been observed in the sandstone at Beechville, the bed will be considered, tepmorairly at least, as a northern representative of the Rosiclare sandstone, by reason of its peculiar lithologic character and its stratigraphic position. Whether any of the subjacent limestone beds are referrable to the Ste. Genevieve limestone has not been determined, either at Beechville or in the Alton section.

PENNSYLVANIAN.

Pre-Pennsylvanian unconformity.—The Pennsylvanian or Coal Measure strata occupy a large area of Calhoun county south of the fault line, and the unconformity of these beds upon the St. Louis limestone of the same region is distinctly shown, although the strata of both formations are horizontal in position. In a hollow three-fourths of a mile north of Martin's Landing a sandstone of Coal Measure age is exposed at an elevation of forty feet above the river, while at a point fifty yards distant the St. Louis limestone outcrops at an elevation twelve feet higher, and in the river bluff one-fourth of a mile distant the top of the St. Louis is at an elevation of ninety-two feet above the river. These occurrences indicate at least fifty feet of relief in the uneven surface of the St. Louis limestone beneath the Coal Measures, and similar conditions may be seen elsewhere in the region, especially near Golden Eagle.

North of the fault line, Coal Measures strata occur on the summit of the divide southeast of Batchtown, resting upon the Burlington limestone, an occurrence that would indicate that dislocation took place along the fault line in pre-Pennsylvanian time, after which the region suffered erosion down to the St. Louis limestone on the south or downthrow side of the fault, and to the Burlington limestone on the north or upthrow side of the fault. The unconformity at the base of the Pennsylvanian represents the time during which this dislocation and erosion was accomplished, although the present elevation of the base of the Pennsylvanian on the two sides of the fault shows that further dislocation took place along the same line in post-Pennsylvanian time.

Coal Measure sandstone.—The basal member of the Pennsylvanian is a sandstone of varying thickness which has filled the inequalities in the upper surface of the St. Louis limestone, the upper surface of the sandstone apparently being approximately horizontal. This sandstone is more or less ferruginous, sometimes conglomeratic, and often cross-

* Ulrich, U. S. Geol. Surv., P.P. No. 36, p. 40; also Bain, U. S. Geol. Surv., Bull. No. 255, p. 22.

bedded. At one point near the brickyard at Golden Eagle the contact of the formation with the St. Louis limestone is clearly shown, and in its basal part it contains a considerable amount of carbonaceous matter of vegetable origin.

North of the fault line, in the heads of some of the ravines southeast of Batchtown, numerous blocks of ferruginous sandstone are irregularly tumbled about, but in no case have they been observed *in situ*. In several cases, however, it can be clearly seen from the position of the blocks, that their original position was above the Burlington limestone, and in one ravine a hard, yellow, ocherous shale occurs, apparently *in situ*, which is in close association with the blocks of sandstone. In this shale there are many small rod or needle-like bodies, pointed at one or both ends, which are clearly fossils, although their relationships are uncertain. Entirely similar bodies, however, are not infrequently present in the coals and associated shales throughout the Coal Measures in Illinois and elsewhere, and on account of this it seems reasonable to assume that the sandstone and shale on top of the divide are of Pennsylvanian age, and the sandstone is probably to be correlated exactly with the basal Coal Measure sandstone south of the fault line.

In the region south of the fault line the base of the Coal Measures follows more or less closely the 500 foot contour, but the occurrence of the same sandstone north of the fault is very close to the 700 foot contour. The throw of the fault, as indicated by this dislocation of the beds, would be 200 feet. As indicated by the older formations, however, the Niagaran limestone on the upthrow side and the St. Louis limestone on the downthrow side, at a point south from the occurrence of the Coal Measure sandstone near Batchtown, the total throw of the fault is not less than 290 feet. This discrepancy is accounted for by the fact that the faulting took place at two distinct periods, first after the deposition of the Mississippian formations a fault with a throw of approximately ninety feet was developed, and in Post-Pennsylvanian time additional faulting to the extent of 200 feet more was developed.

Fire Clay and Coal. The best exhibition of the beds of the Coal Measures lying above the basal sandstone, may be seen at the coal and fire clay mine at Golden Eagle. At this point a bed of fire clay from five to eight feet in thickness is mined, between which and the basal sandstone is, first a bed of clay from one and one-half to four feet thick, filled with concretions, and below this about ten feet of blue clay and shale.

Immediately above the fire clay is a two foot coal seam which is mined with the clay. About two feet above the first coal is a second seam nine inches thick, which is followed by the "cap rock" fourteen inches thick.

Outcrops of the coal seam with the underlying fire clay are frequent in the ravines on both the east and west sides of the divide, although the beds are much better exposed in the valleys of the streams flowing to the west. Both beds doubtless underlie the entire Coal Measure area south of the fault line in Calhoun county.

Coal Measure shale. Above the beds just described is a series of about seventy-five feet of shales. The lower fifty to fifty-five feet are of a yellow or greenish-yellow color, and are slightly gritty in texture. Above the yellow shales there are about twenty feet of shales similar in texture to those below, but different from them in having a rich chocolate-brown color. This shale formation is very uniform in character throughout the entire region where it occurs, and the chocolate shales especially are more or less well exposed near the heads of most of the ravines running west from the divide.

Coal Measure limestone. The chocolate shales are succeeded by a hard, fine textured, bluish-gray limestone, probably not exceeding twenty feet in thickness, which caps the divide throughout the area occupied by the Coal Measures. Great tumbled masses of this limestone are almost uniformly present in the heads of the ravines on the west side of the divide, the outcrops being less well exposed in the ravines extending to the east.

Fossils are frequently abundant in this limestone, but a large variety of species has not been observed. The commonest form is *Reticularia perplexa,* which frequently occurs in vast numbers, associated with an occasional specimen of *Productus* or *Seminula.*

TERTIARY.

Lafayette gravel. On top of the divide beneath the loess montle, from Conrad to the southern extremity of the county, occurs a deposit of gravel having all the characteristics of the Lafayette gravel as exposed near Glencoe in St. Louis county, Missouri. This gravel consists of very perfectly rounded pebbles ranging in size from a pea to eighteen inches or more in diameter. The materials are of various sorts, chert, vein quartz, and quartzites, the large majority of which are foreign to the region. In the more southern portion of the region, especially near Golden Eagle where the formation becomes much more conspicuous and contains much larger pebbles and boulders than further north, the purple Sioux quartzite is one of the conspicuous materials present. In no case has the formation been observed actually *in situ,* although at the heads of many of the ravines in the region the material could not have been shifted to any great extent from its original position. At the postoffice at Golden Eagle characteristic pebbles of the formation were seen which had been thrown from a cistern excavation several years ago, and one who was present at the time the excavation was made, described the gravel as having been imbedded in a red clay matrix.

The character of these gravels leaves little doubt as to their origin, and their position on top of the divide is such as to make it entirely probable that an undisturbed body of the Lafayette formation is present in the region.

PLEISTOCENE.

Loess. In none of the region south of Bachtown at least, is there any evidence whatever of the presence of glacial drift. The region, however, is covered with a mantle of loess ranging from 10 to 50 feet

in thickness, which obscures, in many places, the underlying formations. This loess is typical of the formation as it occurs in this portion of the Mississippi Valley region, and at some localities contains fossil land shells.

Economic Geology.

The economic resources of southern Calhoun county have been developed to but a slight degree, although they are somewhat varied in character.

Fire Clay.—The fire clay near the base of the Coal Measures is utilized at but a single locality at Golden Eagle. The Thomas Brick and Clay Co. of St. Louis have a plant at this place which is capable of producing 25,000 to 30,000 bricks daily. The clay is mined by drifting into the hill side. It is of a good quality, and is probably the same bed as that which is worked in the Cheltenham district in St. Louis. The company operates a steam transfer capable of carrying six loaded cars, by means of which their out-put is ferried to Peruque, Mo., directly opposite Thomas Landing, where the cars are shipped via the C. B. & Q. R. R., or they are transferred to Grafton by the same means, 12 miles down the river, to be shipped via the C. P. & St. L. R. R. The fire brick manufactured go on the market as "St. Louis No. 1."

This fire clay has a wide distribution in the southern portion of the county, and might be profitably worked at many points, provided the transportation facilities are sufficient. At present the county is dependent exclusively upon river boats, but the building of trolley lines may add materially to the transportation facilities of the region.

The presence of the coal immediately above the fire clay, which can be mined with the clay, is a distinct advantage since it will furnish approximately one-half of the fuel necessary for burning the brick.

Shales.—The yellow or greenish-yellow shale lying above the coal in the southern portion of the county has been used to a limited degree by the Thomas Brick and Clay Co. for the manufacture of pressed building brick of a good quality. This body of shale is easily available at many localities in the region, and its further development doubtless only awaits more convenient means of transportation. The chocolate shales at the summit of the formation have not been tested, but will doubtless prove to be of value for certain purposes.

Other shales in the region are the Maquoketa and Kinderhook shales, more or less continuous outcrops of which occur north of the fault line. Neither of these formations have ever been utilized, but tests which have been made indicate that the Maquoketa beds will at least afford material for ordinary building brick, and there are numerous localities where they might easily be worked. The tests made of the Kinderhook shales are entirely unpromising.

Coal.—The coal worked in connection with the fire clay at Golden Eagle, outcrops in many of the ravines of the region, and has been worked locally to a slight degree from the surface outcrops. The seam doubtless underlies the whole of the Coal Measures area. The bed varies from 24 to 30 inches in thickness, and is too thin to be worked

economically for itself alone, but taken in connection with the subjacent fire clay it might be worked at an advantage elsewhere as it is being worked at Golden Eagle. The quality of the coal is good.

Limestone.—The most important body of limestone in the region is the St. Louis limestone which outcrops almost continuously along the Mississippi river from a short distance south of the fault line to the end of the bluffs above the mouth of the Illinois river. This limestone is well adapted for crushed stone, much of it might be burned for lime, and some portions of the formation would supply a good quality of building stone.

The Kimmswick limestone is of the same character here as in St. Louis and Jefferson counties, Missouri, where it is extensively burned to produce a high quality of lime, and if proper transportation facilities were afforded the lime industry might be developed to a notable degree in the neighborhood of Batchtown.

Other notable limestones of the region are found in the Plattin, Chouteau and Burlington formations, and in the Reticularia bearing limestone at the summit of the Coal Measures, any or all of which might be utilized for road material, and perhaps also for other purposes. Some of the limestones of the region might be utilized in connection with the associated shales, in the manufacture of portland cement.

Dolomite.—The notable dolomite or magnesian limestones of the region are the Joachim and the Niagaran formations. The Joachim limestone has been quarried extensively near West Point for the Mississippi river work, but it is not of a character to be of value for other than rough work or crushed stone. The Niagaran limestone is of the same character and quality as at Grafton where extensive quarries are operated, and the stone in Calhoun county might, with proper transportation facilities be used for the same purposes as the Grafton stone.

Sandstone.—The only bed of sandstone in the region of notable economic importance is the St. Peters sandstone. It is of the same general character in Calhoun county as elsewhere in the Mississippi Valley, where it is the formation most extensively used for glass making. Formerly a quarry of some size was operated at Dogtown to furnish raw material for the glass works at Alton, but during recent years, these works have secured their sand from other sources.

Phosphate.—The phosphate bed immediately above the Maquoketa shale is worthy of further investigation and may prove to be of considerable economic importance, although the tests so far made are not promising. It is at essentially the same geologic horizon as one of the phosphate beds so extensively worked in the south, and if it should prove to be of sufficient extent to be of economic value, it would become a valuable addition to the resources of the county.

WATER RESOURCES OF THE SPRINGFIELD QUADRANGLE.

(By T. E. Savage.)

Contents.

Introduction.—The Springfield quadrangle, as mapped by the topographic division of the United States Geological Survey, embraces an area about 230 square miles in extent, lying in the central and north central portions of Sangamon county, together with small adjacent areas in the southwest corner of Logan and the southeast corner of Menard counties. It is included between 89° 30′ and 89° 45′ west, and latitude 39° 45′ and 40° 00′ north. It is embraced within the limits of townships 15 to 18 north, and ranges IV to VI west of the third principal meridian. The city of Springfield is situated in the southwest one-fourth of the area.

The region is comparatively level, constituting a portion of the great prairie plain of central Illinois. The maximum topographic relief of the area does not exceed 150 feet. The major surface inequality consists of a broad depression crossing the central and southeastern portions of the quadrangle, which has been developed by the erosion of the Sangamon river and its tributaries and their pre-Pleistocene progenitors. The most prominent elevations which occur in the quadrangle are found near the northeast corner. They consist of a number of mounds and ridges that rise abruptly to a height of thirty to fifty feet above the level surface of the upland prairie. These are composed largely of sand, and seem to have been formed through the combined agency of ice and water under conditions attending the melting of the last glacier from this region.

Stratigraphical Relations.—All of the country rock that is exposed over this area belongs to the Coal Measures or Pennsylvania series. It consists of alternating beds of shale and sandstone, occasional narrow

bands of limestone, and thin seams of coal. The materials that overlie the indurated rocks include deposits of sand and loess, and two different beds of till, known respectively as the Kansan and the Illinoian. These sheets of till are often separated from each other by a layer of loose sand, which varies at different points from one to five inches to as many feet in thickness. In the northern and northwestern portions of the area these two beds of bowlder clay are separated by an old soil horizon which is black with carbonaceous matter, and contains a large quantity of wood fragments and vegetable debris. Lentils of sand of small extent occasionally occur within the body of a single sheet of till. This till, or bowlder-bearing clay, is known by the well drillers as "hard pan." The upper surface of the bowlder clay is in many places covered by a layer of sand or fine gravel. The material of this layer represents a concentration of the coarser constituents of the till by the sorting action of water. The bed varies in thickness from nothing to eight or ten feet. It is usually overlain with a mantle of loess to a depth of from five to fifteen or more feet. The present soils of the region have been developed upon the surface of the yellow, fine-grained deposit of loess.

The larger streams of the area flow in valleys that are at least older than the upper sheet of till. Their channels were carved in the indurated rocks to a depth which at one point is known to be more than seventy-five feet below the level of their present beds. The alluvium of these flood-plains consists of layers of sand and clay or of fine gravel, or a mixture in varying proportions of these materials.

Water horizons and wells.—In general the conditions for a water-bearing bed are: First, a layer of porous materials, such as sand or gravel, in the spaces between the grains of which water is held and through which spaces it readily percolates. Second, these porous beds must rest upon, or be inclosed between, layers of impervious material. The water reservoir is generally fed by the storm water that sinks into the ground over areas, usually of higher altitude, in which the porous layers outcrop at the surface.

The above conditions are met at a number of horizons over the Springfield quadrangle. Where the loess is deep, and where this thick deposit is underlain with sand, these materials constitute one of the most important water-bearing beds. The porous character of the loess permits of the ready absorption of water, and the underlying impervious bed of bowlder clay holds the water near the surface.

Out of 756 well records that were obtained in the Springfield quadrangle, and from a belt one-half mile in width around its border, 476 report the water supply from above the hard pan or till. These are dug wells and are pretty generally distributed over the quadrangle. Out of the total number of records, 391 are so complete that the horizon of the water-bearing bed can be determined with a good degree of assurance. Of this latter number, 209 of the wells, or about 54 per cent, stop at the hard pan or penetrate it but a very little distance. The records indicate definitely that the water-bearing horizon is a layer of sand above the hard pan. The average depth of this sand bed below the surface is about 21 feet. That this layer of sand is not continuously present above the till is shown by the fact that many wells pass from the

pebbleless, yellow clay directly into the pebbly clay of the till. Where the sand bed is a few inches or more in thickness it yields an abudant supply of water for farm wells.

Where the streams have cut their channels through the loess and sand into the underlying drift, springs frequently issue along the line of contact of the porous materials with the surface of the impervious bowlder clay. The surface of this sand layer is somewhat undulating. In a general way it corresponds with the present topography of the region, being higher over the uplands and dipping downward as the stream channels are approached.

Another water horizon is furnished by the layer of sand that at many points is found between the Kansan and the Illinoian drift sheets.

Out of the 391 well records which contain definite information on the water horizons, 55, or about 14 per cent, report the water as coming from sand between two beds of hard pan. This information could only be obtained where the wells were put down a few feet below the aquifer, so as to furnish a reservoir for the water.

In a number of records of wells of this class the water is reported as "gushing up" when the overlying hard pan was broken through. The catchment area of such aquifers is generally at a distance from the wells. The supply of water is not obtained from the ground water in the immediate vicinity of the well, and hence it is not so sensitive to the seasonal fluctuations of the water table as in the wells of the former class. Of the 55 wells above mentioned, the average depth of the sand bed or water horizon below the surface was 35 feet. The average thickness of the upper, or Illinoian till, as definitely reported, was about 20 feet. The greatest thickness reported was 86 feet; penetrated in a boring on the farm of George Gregory in section 26, T. 16 N., R. 6 W. The variation in the thickness of this bed of drift is owing in part to the irregular distribution of its material by the glacier, but to a much greater extent it is due to the fact that the deposit was spread unconformably over the eroded surface of an older drift sheet, and that the upper surface of the till has also been considerably trenched by the streams. Thus both its upper and lower surfaces are more or less uneven.

In 23 of these wells a buried soil horizon, containing numerous wood fragments and designated by Leverett as the Yarmouth zone, was passed through at an average depth of 25 feet. These wells are mostly situated in the northern and northwestern portions of the quadrangle. They are especially numerous in the vicinity of the town of Athens. This zone of buried soil was reported from a well in section 26, T. 16 N., R. 6 W., a point considerably further south than the principal area over which it occurs. It was struck here at a depth of 99 feet, a depth much greater than was reported from any other well. The water from such wells is usually dark colored, has a bad odor, and is unfit for use. The surface of this soil is somewhat uneven. In places its level changes 20 feet within a distance of one mile. It is highest along the north side of the quadrangle, and has a general southward

slope. Its elevation varies from 602 feet near the middle of the north line of the area to 493 feet in section 26, T. 16 N., R. 6 W., the most southerly point at which it was found.

In 83 of the records the wells are reported as obtaining water from the hard pan without any definite water-bearing layer. Inasmuch as the materials of the till do not permit the ready percolation of water, such wells are weak, and a number of them were reported dry. Out of the total number of records 103 are reported to have struck rock or penetrated it to varying depths. The average depth to the Coal Measure strata in these wells was 27 feet. In 86 of these the water is obtained from the base of the till, immediately above the country rock.

The above mentioned depth of the surface matrials does not represent its average thickness over the quadrangle. Leverett found the average depth of the Pleistocene materials over the pre-glacial uplands of the Illinoian drift area to be about 40 feet.* The greatest depth of surface materials penetrated by borings in this area was 170 feet, but this well did not reach rock. It was on the land of George Van Eman, in section 23, T. 18 N., R. 6 W., and it is possible that the boring was a pre-glacial valley. However, a number of wells over the uplands were put down in the drift 40 to 50 feet without finding rock.

The well records show that a ridge of Coal Measure materials, 5 to 6 miles in width, extends in a northwest-southeast direction across the north half of the quadrangle. No rock was reached along the west border, or over an area thirty square miles or more in extent, in the northeast portion of the quadrangle, although many of these wells went down to altitudes lower than that of the top of the rock ridge further west.

A drift filled gorge, having a known depth of at least 140 feet, extends for a width of two to three miles along the west side of our area. The west bank of this valley lies outside the quadrangle, and its position was not determined. The VanEman well, above described, stopped in drift at an altitude of 440 feet. Two miles east of this point, rock outcrops at the surface at an elevation of 580 feet above the sea. In section 23, T. 17 N., R. 6 W., a well on the land of W. F. Irwin was drilled on the edge of the flood-plain of the Sangamon river to a depth of 93 feet, stopping in alluvium at 472 feet altitude. Four miles east of this place rock was struck in a well at an elevation of 570 feet. The entire depth of this pre-glacial channel is not known. Over the south half of the quadrangle the records indicate that the rock surface has a relief of not less than 100 feet. The wells here, in which Coal Measure beds were encountered, were generally at no great distance from streams where erosion had removed a portion of the original drift covering. In 17 wells the source of the water was reported to be a layer of Coal Measure sandstone. The water horizons of the Coal Measures seem to lie at different altitudes. The head of water in good wells of all the different classes in corresponding topographic areas, is so near the same as to suggest that these sandstone layers may be fed with water that has percolated into the rock from the overlying Pleistocene

* Leverett, Illinois Glacial Lobe, Mon. XXXVIII, U. S. Geol. Surv., p. 546.

materials. The deepest drilling reported was 280 feet, penetrating 250 feet of Coal Measure strata. This was on the land of H. Lainhart, in section 22, T. 18 N., R. 5 W. In section 2, T. 16 N., R. 4 W., a well on land of Annie Taylor is 175 feet deep, and passed through 140 feet of rock. Two wells are reported from section 1, T. 15 N., R. 5 W., which go down 150 feet, penetrating rock 120 and 140 feet respectively. In none of these wells was the water horizon known. In all four of the wells the water level was about as near the surface as in neighboring wells fed from the surface materials, the head being respectively at 25, 20, 18 and 15 feet below the curb. The altitude of the bottom of the wells was respectively 331, 388, 440 and 434 feet.

That aquifers in the Coal Measure beds do not extend continuously over the area is shown in a boring on land of Fred Long, in section 32, T. 16 N., R. 5 W., which penetrated 150 feet of rock without finding water. The same fact is indicated in a number of other wells of lesser depth, and by the coal shafts in the quadrangle. There are 29 of these shafts, ranging in depth from 150 to 265 feet. In none of these was a strong aquifer encountered, nor does water find its way into any of the mines in sufficient quantity to cause serious annoyance. Mr. J. K. Smith, a veteran well driller of Riverton, reports that in his experience no water was found in the Coal Measures below the thin coal seam that outcrops in the banks of the streams in that region. About a dozen of the wells were reported as obtaining water from the alluvium of the flood-plains of the river and its larger affluents, at a depth of from ten to twenty-five feet. The Springfield city water works pumps a portion of its water from the Sangamon river, while the balance is obtained from filter galleries in the sand and gravel of its flood-plain. It is probable that a large proportion of the water that is drawn from the filters comes from the ground water of the alluvium and not from the river itself.

The water table.—In the following discussion the surface of the water table, or the height to which the ground is saturated with water, was assumed to be the level at which water stood in the various wells. This level varies considerably from time to time, becoming higher after heavy rains, or during seasons of excessive rainfall, and sinking lower during periods of drought. In cases where a considerable amount of water is used from weak wells, fed from the drift or from below the surficial materials, the assumption made above would not be quite true. While a bed of till may be saturated it does not readily part with its water, and hence for certain periods the slow percolation into the well may not equal the quantity drawn out from day to day. In such cases the head of water in the well may be some distance below the actual level of the water table. The percentage of such wells in the area is small, and the records of the water surface approximate the actual conditions at the time the records are obtained.

The well records of the Springfield quadrangle gathered during the summer of 1906 show that over the level upland areas, some distance from the streams, the water table lies within five to eight feet of the ground surface. The older settlers of the region report that before the farms over these areas were generally tiled the water stood so near

the surface that it was dipped out with pails from the tops of the wells. This would seem to indicate that the ground water level had been depressed something like two feet, as a result of the cultivation of the land.

As the streams are approached the water table slopes downward with a longer and more gentle gradient than the land surface. This decrease in head towards the present drainage lines is probably due to the escape of the water into the stream valleys. The water table occasionally reaches the surface in the sides of ravines where springs issue from the top of the impervious bowlder clay.

Where deposits of sand are deep the water table stands at a low level relative to the ground surface. This is conspicuous over a belt south of the Sangamon river, in the central portion of the quadrangle, and in the elbow of the river in the west central portion. The ground water level is also very low under the ridges and mounds of sand towards the northeast corner of the area.

Wholesomeness of the water supply.—When a reasonable amount of precaution is taken to prevent seepage from stables, cess pools, or refuse of any kind from draining into the wells, the water from the farm wells over the quadrangle seems to be generally wholesome. The difficulty of preventing contamination of the water in town wells is much greater.

Dr. F. F. Hill, of Athens, reports that occasional cases of typhoid fever occur in that town nearly every summer. During 1903 there were fifteen cases in which he attributed the infection to contaminated drinking water. The horizon of buried soil and vegetable debris is encountered in a number of wells in that vicinity, and it is possible that this was an important source of water pollution.

Dr. T. W. Priest, of Williamsville, states that he knows of no case of fever in that community which could be traced to impure water, although the supply is all obtained from shallow wells.

Dr. John Deal, of Riverton, reports that they have had no epidemic or fever in that town for twenty-eight years, and their water is all furnished from surface wells.

About one-half of the water supplied to the city of Springfield by the Springfield water works is taken from filter galleries along the banks of the Sangamon river. The other half of the water is pumped direct from the river into the mains without being filtered. By thus mixing the filtered and the unfiltered water, the entire supply is rendered practically as impure as the unfiltered part taken from the river. The following analyses of the water supplied by the Springfield water works has been furnished through the kindness of Dr. Edward Bartow, Director of the State Water Survey:

Analyses of Water Supplied by the Springfield Water Works—Parts per Million.

Date.	Turbidity.	Sediment.	Color	Odor	Total residue	Disolved residue	Chlorine	Oxygen Consumed	Free ammonia.	Albuminoid ammonia.	Nitrites	Nitrates
May 2, '98	Slight	Little	.03	.00	259.2	36.8	5.0	2.3	.196	.070	.001	.45
June 1, '99	Slight	Little	.01	.00	108.	.00	.81	.6	.348	.032	.011	.16
Nov. 6, '00	Slight	Little	.02	.00	268.8	19.2	3.8	3.3	.052	.138	.000	.8
May 21, '02	Distinct	Little	.3	.00	298.8	50.8	4.5	2.7	.12	.048	.003	.397
May 21, '02	Decided	Considerable	Yellow	.00	285.2	20.	5.1	3.6	.528	.086	.000	.27
May 21, '02	Distinct	Little	Muddy	.....	285.6	25.2	4.7	3.1	.036	.030	.000	.64
May 21, '02	Decided	Considerable	Muddy	.....	339.6	39.2	5.1	4.1	.088	.256	.070	2.33
Feb. 1, '03	Distinct	Little	.1	.....	290.	28.0	4.1	3.	.112	.114	.003	.557
Feb. 1, '03	Slight	Little	.0	.....	183.2	26.4	4.0	5.7	.064	.224	.003	.118
Feb. 1, '03	Distinct	Little	.1	.....	289.2	21.8	4.0	2.3	.032	.098	.003	.597
Feb. 1, '03	Distinct	Little	.1	.....	284.0	28.8	4.05	2.3	.064	.098	.014	.666
Aug. 23, '05	Decided	Considerable	Muddy	.....	232.4	.....	5.6	6.35	.060	.182	.000	.040
Aug. 23, '05	Decided	Considerable	Muddy	.....	284.0	.....	8.0	5.5	.036	.144	.000	3.6
June 11, '06	Distinct	Considerable	Muddy	1 Earthy.	437.	.....	6.0	3.4	.056	.376	.000	.64

The considerable variation in the residue shown by the above analyses is of interest. It will be noted that most of these analyses are old. The one taken in 1906 represents water taken from the city mains at a time when it was particularly bad and does not represent average conditions.

The considerable variation in the residue shown by the above analyses is of interest. It will be noted that most of the analyses are old. The one taken in 1906 represents water from the city mains at a time when it was particularly bad and does not represent average conditions.

R. M. Ridgley, superintendent of the Springfield water works, states that about three-fourths of the population of Springfield use city water. This means that nearly 10,000 people in the city depend for their water upon shallow wells, the most of which go down only to the layer of sand above the till. The danger of water pollution in shallow wells in a large city like Springfield is great. The unwholesome character of the water from this source is shown by the following analyses, kindly furnished by Dr. Bartow:

Table of Analysis of Water from Wells in the City of Springfield. Parts per Million.

Date of Collection.	Turbidity.	Sediment.	Color.	Odor.	Total Residue.	Chlorine.	Total Oxygen Consumed.	Free Ammonia.	Albuminoid Ammonia.	Nitrites.	Nitrates.	Depth of Well Feet.	Remarks.	Sulphates.
November 20, 1905	Clear	Little	None	Earthy	1.533.	49.	3.6	.050	.050	.760	26.460	25	Bad.	Very much
October 16, 1905	Distinct	Little	None	Earthy	481.	9.5	1.25	.038	.050	.000	.28	20	Good	Much
October 16, 1905	Very slight	Little	None	None	452.	15.5	1.85	.056	.056	.001	.32	20	Fair	Much
September 5, 1906	Clear	Very little	None	None	1.090.	79.5	2.1	.012	.036	.003	2.40	30	Bad.	Very much
October 17, 1906	Slight	Little	None	None	2.018.	107.0	4.1	.214	.068	.550	62.	.....	Bad.	Much
September 23, 1905	Clear	Little	None	None	720.8	31.5	2.75	.040	.078	.003	4.397	30	Bad.	Very much
August 23, 1905	Clear	Very little	None	None	830.4	40.5	2.55	.032	.040	.023	21.977	25	Bad.	Much
August 29, 1905	Clear	Very little	None	Musty	1.562.0	80.0	3.25	.040	.090	.550	34.45	40	Bad.	Much
August 1, 1905	Clear	Very little	None	None	1.035.2	73.5	2.25	.064	.108	.050	26.0	18	Bad.	Considerable
June 21, 1902	Decided	Considerable	Muddy	None	339.6	5.1	7.6	.008	.256	.07	†2.33	.....	.....	.....
*October 29, 1901	.....	.....	.....	.....	1.334.8	11.	2.	.28	.064	.001	.16	.....	.....	Considerable

* Considerable iron was also present in the water from Washington Park spring.
† Sangamon river at Water works intake.
‡Mineral spring, Washington Park, S, ringfield.

Possibility of Deep Water Supplies.—In general, water from deep wells is much more free from pollution by micro-organisms than that from any other source, though it is apt to be heavily mineralized. No deep borings have been made within the limits of the quadrangle. Mr. H. S. Upham has a flowing well at Jacksonville, about thirty-five miles west of Springfield. The total depth of this boring is 3,028 feet. The water comes from the St. Peter sandstone, which was reached at a depth of 2,028 feet. The well is reported as flowing at the rate of 500 gallons per minute. This would be equivalent to 720,000 gallons per day. Estimating the quantity of water required for each person per day at thirty-five gallons, two such wells as this would furnish an abundance of water for the entire population of Springfield. Mr. Upham has a second flowing well 3,110 feet in depth. This well is also supplied with water from the St. Peter sandstone. Mr. F. Sibert has a similar well 3,100 feet deep which is fed from the same sandstone. At Petersburg, in Menard county, a well was put down on land of L. E. Hartrick to a depth of 2,011 feet. This is also reported as a flowing well. Dr. W. A. Gray, of Peoria, obtained a strong well at 215 North Adams street, at a depth of 980 feet. The water contains a considerable amount of sulphur and stands thirteen feet below the curb.

In general, the geological conditions in the Springfield quadrangle are not greatly different from those at the points above mentioned. It is probable that artesian water could be found at a depth corresponding quite closely with that of the Jacksonville wells. Unfortunately the water from these wells is so highly mineralized as to be unfit for boiler uses and general purposes, and there is no reason to suppose that a better quality would be found at Springfield.

THE MINERAL INDUSTRY IN 1906.

(By H. Foster Bain.)

Introduction.—Statistics of mineral production showing the output of the State for the year 1905 were collected by Mr. F. B. VanHorn in coöperation with the U. S. Geological Survey. These statistics were published in a special circular and distributed late in the summer. It is impossible at this time to give statistics for the year 1906, but the following review of the year prepared in December and published in The Mining World of Jan. 26, last, may not be without interest.

Oil and Gas.—The sensational feature of the year in Illinois was the rapid increase in the production of petroleum. The oil and gas fields of the southeastern part of the State began shipping in June, 1905. They were first described by A. W. Lewis, of the State Geological Survey, in The Mining World of April 14th, 1906. A report upon the area, prepared by W. S. Blatchley, was published as Bulletin 2 of the survey in August. In 1905 these fields produced 156,502 barrels of petroleum. In the first 10 months of 1906 the output amounted to 3,588,705 barrels, and was increasing at the rate of approximately a half million barrels a month. In August over 800,000 barrels were shipped but a reduction in price shortly afterwards decreased the monthly output During the year the fields have been extended rapidly to the southeast, till now there is a considerable production from Westfield in Clark to Bridgeport in Lawrence county. It is estimated that over 400 wells have been drilled. Considerable quantities of natural gas also have been found, though very little is being utilized. The rock pressure varies from 185 to 420 pounds, and seven wells tested by B. A. Kinney showed a combined daily yeild of 48,200,000 cubic feet. Pending an anti-gas waste law, which will probably be passed by the General Assembly this winter, there is little inducement to attempt to utilize this fuel.

Wild catting in other parts of southern Illinois continues. The results so far have been encouraging but not sensational.

Coal. The coal mines furnish approximately two-thirds of the annual mineral output of the State. According to revised figures the output in 1905 amounted to 38,434,363 short tons, wtih a value of $40,577,592, as determined jointly by the State and U. S. Geological Surveys. A long and bitterly contested strike in the early part of the year and unusually severe car shortage in the fall, have combined to discourage the producers. It does not seem likely, however, that these factors have decreased the total output. Indeed State shipments into and through Chicago increased 31 per cent in the first 10 months of 1906 as compared with the preceding year, and similar shipments into St. Louis show an increase of 27 per cent. The coincidence in these figures is striking, but it is not likely that such a sensational increase

for the State as a whole is to be anticipated. It may none-the-less be confidently predicted that the returns for 1906 will show a larger output than for 1905. It is well known that the field is equipped to supply a much larger demand than present markets and shipping facilities permit.

A number of important new mines have come into production, but there has also been a marked improvement in shipping facilities. The southern Illinois field continues to attract attention and gain most rapidly. The Big Four improvements are nearing completoin, the Burlington line to Herrin has been connected with additional mines and is projected to the Ohio river; the Illinois Central and other roads have been building much needed switches and terminal lines, and a number of new washers are being constructed.

Clay. The clay products of Illinois amount now to more than $10,000,000.00 and the industry in 1906 showed a healthy condition. There was an especial demand for building brick, and the output will probably show a notable increase. The search for fire clays, which has been going quietly forward, has resulted in the discovery of several valuable deposits. At least a half dozen clays are now known which will withstand high temperature. Just what range of usefulness they may have is being investigated.

Quarry Products. The demand for stone of all kinds has been good. Illinois is relatively deficient in developed quarries of dimension stone, but the crushed rock output is rapidly growing. The steam shovels in the large quarries of Vermilion county, from which limestone is taken for flux in the Chicago blast furnaces, were busy. An additional tract of 1,000 acres was purchased and is to be developed.

Cement. The Portland cement mills of the State were busy as usual. A new plant is building at Dixon, and the land is said to have been bought near Port Byron for still another. It remains true that the cement industry here has not in recent years grown as rapidly as in neighboring states, despite abundant rock and clay, cheap fuel and convenient transportation facilities.

Sand and Silica. The glass and building sand industries have been in a healthy condition. A large new mill has been erected to prepare the silica of the southern part of the State for market, and another is in contemplation. A deposit of ochre of workable grade has been discovered but has not yet been developed.

Lead and Zinc. The Illinois zinc smelters have had a busy year. The Depue works of the Mineral Point Zinc Co., have gone partially into commission. The Hegeler works at Danville are not yet ready to receive ore.

In Jo Daviess county a number of old properties are being drilled. The shaft of the Stacey Diggins is down, and is said to confirm fully the excellent showing made by their prospect drill holes. In the southern part of the State a small but steady production of lead is maintained as a by-product from the fluorspar mines. It has long been known that this lead carries some silver. An interesting development of the new year was the shipment of galena carrying eight ounces and more of silver, which at present more than pays the freight on the shipments.

Fluorspar. The Rosiclare and Fairview mines continue to be the main producers, and are now excellently situated to meet all demands. The new mine of the Fairview is giving satisfaction. At the Rosiclare a Hancock jig is being installed. Three mines at Lead Hill have reached a productive stage, and the Bay City mine has also made shipments.

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The list of publications is as follows:

Bulletin 1. The Geological Map of Illinois; by Stuart Weller. Including a folded, colored geological map of the State on the scale of 12 miles to the inch, with descriptive text of 26 pages. Gratuitous edition exhausted. Sale price *45 cents.*

Bulletin 2. The Petroleum Industry of Southeastern Illinois; by W. S. Blatchley. A preliminary report descriptive of condition up to May 10th, 1906. 109 pages. Gratuitous edition exhausted. Sale price *25 cents.*

Bulletin 3. Composition and Character of Illinois Coals; by S. W. Parr; with chapters on the *Distribution of the Coal Beds of the State,* by A. Bement, and *Tests of Illinois Coals under Steam Boilers,* by L. P. Breckenridge. A preliminary report of 86 pages; postage *5 cents.*

Circular No. 1. The Mineral Production of Illinois in 1905. Pamphlet, 14 pages, postage *2 cents.*